

~~CLASSIFIED~~

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

PRELIMINARY SUBSYSTEM

CONTROLS AND DISPLAYS

[U]

LED 480-1

4/23/63

(NASA-CR-117668) PRELIMINARY SUBSYSTEM
CONTROLS AND DISPLAYS (Grumman Aircraft
Engineering Corp.) 38 p

N79-76668

N79-76668

00/54

FF No. 602/A

(PAGES)

~~117668~~
(NASA CR OR TMX OR AD NUMBER)

(CATEGORY)

AVAILABLE TO NASA OFFICES AND NASA
RESEARCH CENTERS ONLY

ABSTRACT

The information contained in this report was presented to MSC at a monthly Crew Systems Meeting. These panels are intended to reflect current information inputs for each subsystem as defined by the task analysis to date. The arrangements of controls and displays are purely functional and are not intended to reflect final positioning in an integrated whole panel.

Future publications of this report will reflect revisions to the panels and functional descriptions.

Code 26512 Eng-23A

Contract No. NAS 9-1100

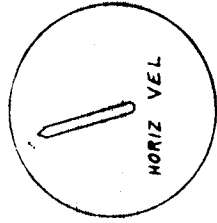
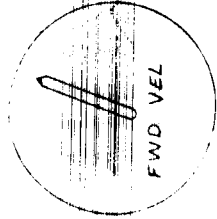
REPORT LED 480-1
DATE 4/23/63

GRUMMAN AIRCRAFT ENGINEERING CORPORATION

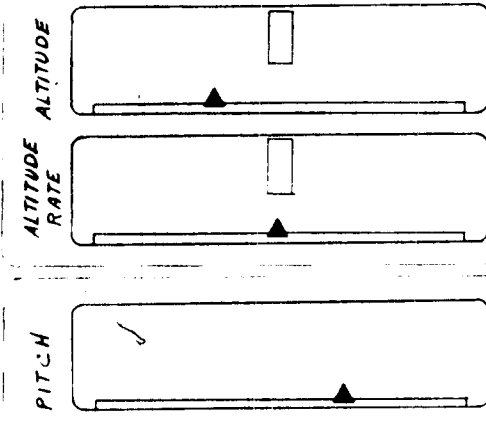
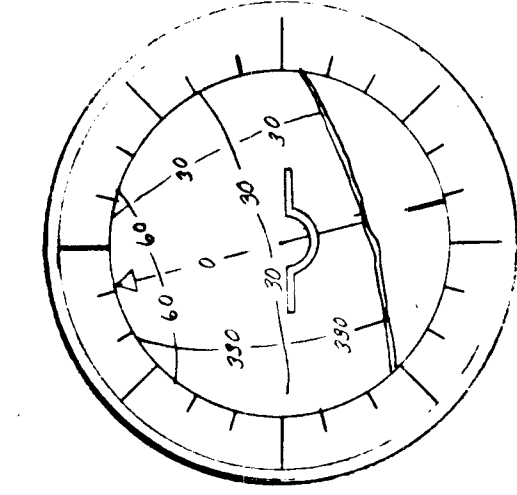
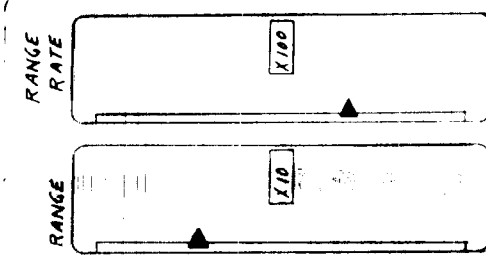
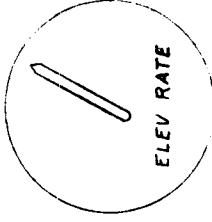
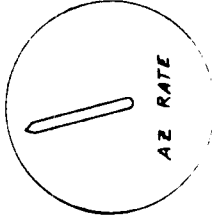
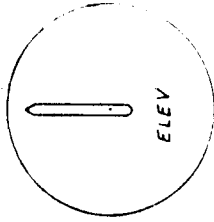
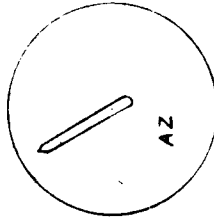
~~CONFIDENTIAL~~

Z65-10657

FLIGHT CONTROL



LINE OF SIGHT



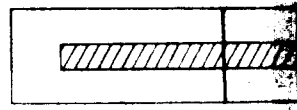
GRD RANGE

+4520

ΔV PANEL

ΔV REMAINING

ANALOG



DIGITAL

35690

ΔV SET

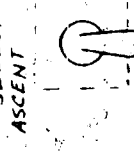


ULLAGE

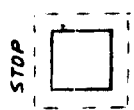
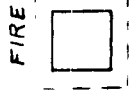


ENGINE MODE

SELECT



ENGINE CONTROL



~~CONFIDENTIAL~~

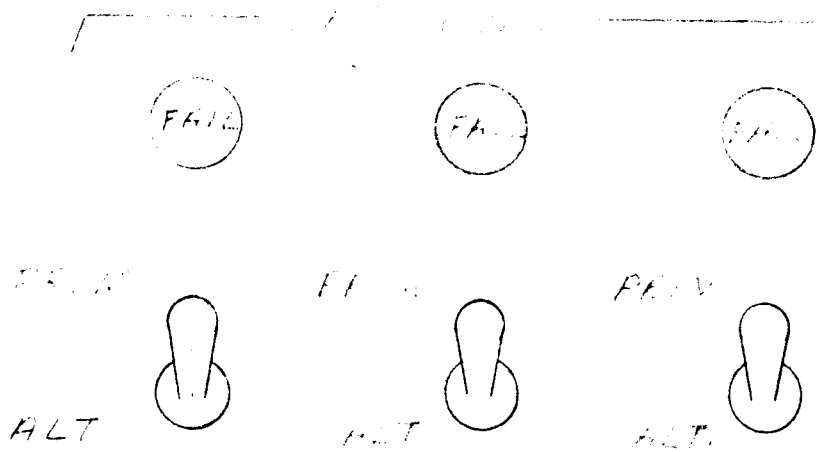
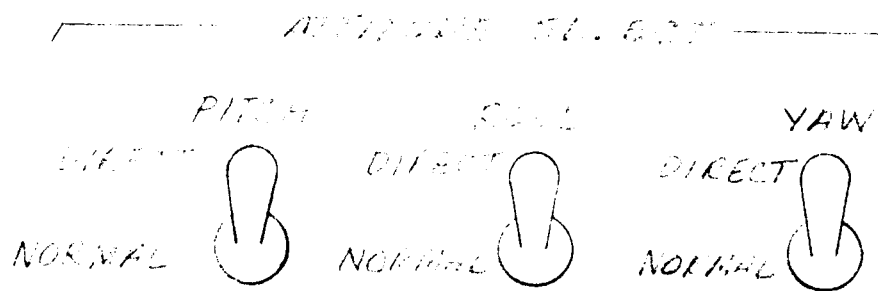
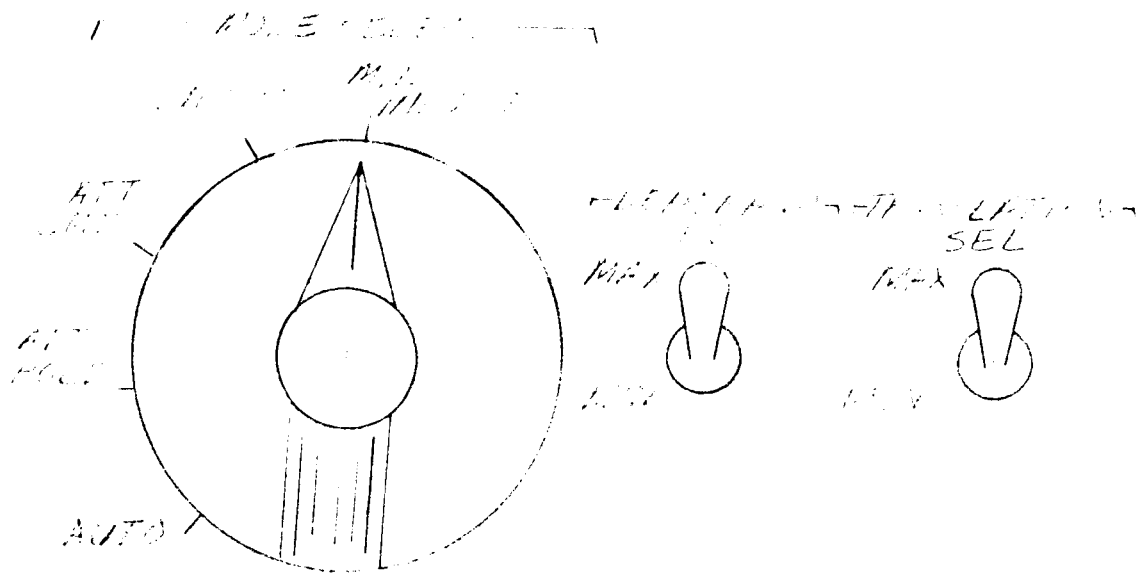
Z65-10657

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
STABILIZATION & CONTROL	1. Attitude Select Toggle Switches	ALL	A 2 position switch (normal - direct) that is provided for each attitude axis. If all 3 switches are in the normal position, whatever is selected by the Mode Select Switch will determine attitude control. If the direct position is selected on any or all of the 3 attitude axes, the pilot is provided only with open loop type acceleration control along the selected axis.
	2. Mode Select Switch	ALL	A 5 position rotary switch which selects the mode of operation provided the attitude select switch is in the normal position. The mode select capability will be auto attitude hold, attitude command direct and minimum impulse. In the automatic position attitude error signals are sent to the S&C subsystem from the Navigation and Guidance subsystem. The attitude error signal is combined with the rate gyro damping signal. The resulting signal then controls the firing of the reaction jets through the logic and pulse generating circuits. In the attitude hold mode the pilot commands an angular rate proportional to displacement of the attitude controller. When the controller is in its neutral position the vehicle will hold attitude. In the attitude command mode the pilot commands attitude proportional to his attitude controller displacement. When the pilot lets go of the stick the vehicle comes back to its original attitude. This mode is mechanized in the pitch and yaw axis only. In the direct mode the pilot is provided only with open loop acceleration control. In the minimum impulse position minimum reaction jet thrusting time for precision maneuvers such as docking is provided.
	3. Deadband Select Toggle Switch	ALL	A 2 position deadband select switch is provided for all attitude axis. In the "max" position a large deadband for coasting period limit cycles where fuel economy is paramount is provided. By throwing the deadband select switch to the minimum position a narrow deadband is provided. This position would probably be used primarily during periods of main engine thrusting.
	4. Rate Gyro Select Toggle Switch	ALL	A two position switch that selects either the primary or alternate rate gyros. There is 1 switch per attitude axis.
	5. Rate Gyro Warning	Emergency	These lights provide rate gyro failure indication. There is one light provided per attitude axis and if a light should come on the alternate rate gyro should be selected along the affected axis. By selecting the alternate position the failure light should go out.
	6. Translation Select Toggle Switch	ALL	A two position switch which by itself determines 3 axis translational capability. In the maximum position translation along an axis selected by the translational controller will occur for as long a period of time as the controller is activated. In the minimum position minimum reaction jet thrusting time is provided for precision maneuvers.

~~CONFIDENTIAL~~

STABILIZATION & CONTROL



~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

4

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
ASCENT/DESCENT	1. Monitor Select Toggle Switch	ALL	Selects the meters and warning lights to monitor the ascent or descent functions.
	2. Ascent Pressurization pushbutton guarded switch (1 for Ascent)	Pre-Separation	Opens the squib valves downstream of the helium tanks. Since the squib valves downstream of the pressure regulators are normally closed, igniting the helium squib valves will pressurize the ascent system down to the ARM squib valves.
	3. Descent Pressurization pushbutton guarded switch (1 for Descent)	Pre-Separation	Used to explode the helium squib valves. Since all valves downstream of the helium squib valves are normally open, igniting the helium squib valves will pressurize the descent system down to the bi-propellant valves.
	4. Fuel Quantity Meter	ALL	Monitors the fuel quantity in tank 1 and tank 2 of either the ascent or descent systems.
	5. Oxidizer Quantity Meter	ALL	Monitors the quantity of oxidizer in tank 1 and tank 2 of either the ascent or descent system.
	6. Fuel and Oxidizer Pressure Meter	ALL	Monitors the pressure of the fuel and the oxidizer tanks of either the ascent or descent system.
	7. Fuel and Oxidizer Temperature meter	ALL	Monitors the temperature of the fuel and the oxidizer tanks of either the ascent or descent system.
	8. Helium Temperature and Pressure Meter	ALL	Monitors the helium tank pressure and temperature of either the ascent or descent system.
	9. Chamber Pressure Meter	ALL	Monitors the engine chamber pressure in either the ascent or descent engines.
	10. Pressure Regulator Warn Indicator lights (2 for ascent and 2 for descent)	ALL	If a pressure regulator malfunctions (pressure differential tolerance exceeded) the appropriate fail indicator light will illuminate, warning the crew of the failure and directing shutdown of that leg. When the PRESSURE REGULATOR SHUTOFF toggle associated with that leg is placed to the OFF position, the fail light will extinguish.
	11. Pressure Regulator Shutoff toggle switches (2 for ascent and 2 for descent)	ALL	These latch-type solenoid valves are located upstream of the pressure regulators in each leg. The valves are normally in the Open position. A pulse from the toggle switch will trigger the solenoid to the OFF position.
	12. Relief Valve Warn indicator lights (2 for ascent and 2 for descent)	ALL	If a pressure regulator malfunctions (pressure differential tolerance exceeded) in one of the redundant legs, the RELIEF VALVE WARN light will illuminate indicating helium vented overboard. The light will extinguish when the pressure is within tolerance limits.
	13. ARM pushbutton guarded switch (1 for Ascent)	Pre-Ascent Checkout	Opens the squib valves downstream of the pressure regulators and upstream of the fuel and oxidizer tanks. Igniting these valves will permit helium to pressurize the ascent system down to the bi-propellant valves.
	14. Bi-Propellant Feed Toggle Switch (1 for Ascent)	Pre-Ascent Checkout	Opens the two isolation valves (solenoid-operated) permitting fuel and oxidizer to flow down to the two thruster valves.
	15. Helium Inject Override Toggle Switch (1 for Descent)	Descent	This control is normally in the AUTO position. In the event the THRUST CONTROLLER does not open the solenoid valve permitting helium flow to the engine inlet during powered descent, this switch should be placed to the OPEN position.

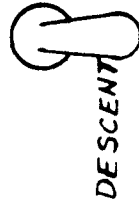
~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

MAIN PROPULSION

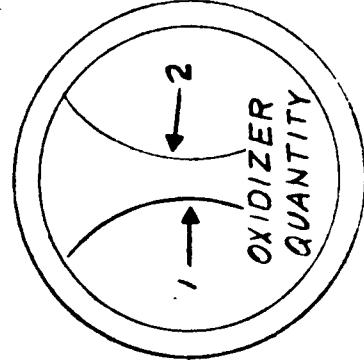
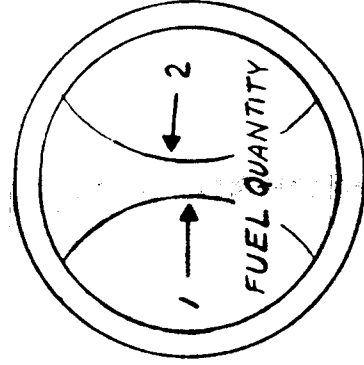
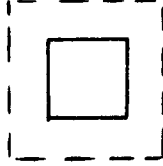
MONITOR SELECT

ASCENT



DESCENT

PRESSURIZATION



PRESSURE REGULATOR WARN

(FAIL) #1

(FAIL) #2

PRESSURE REGULATOR SHUTOFF

NORM OFF #1

NORM OFF #2

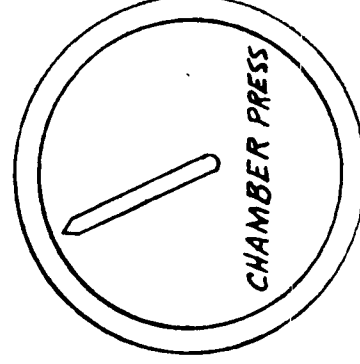
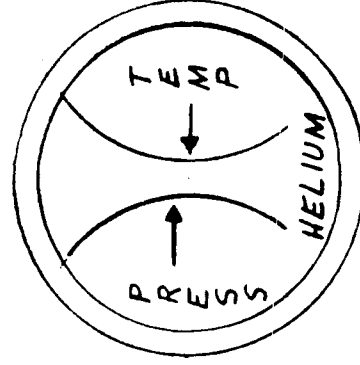
RELIEF VALVE WARN

(FAIL) FUEL #1

(FAIL) OXID #2

HELIUM INJECT OVERRIDE

(FAIL) OPEN AUTO CLOSE



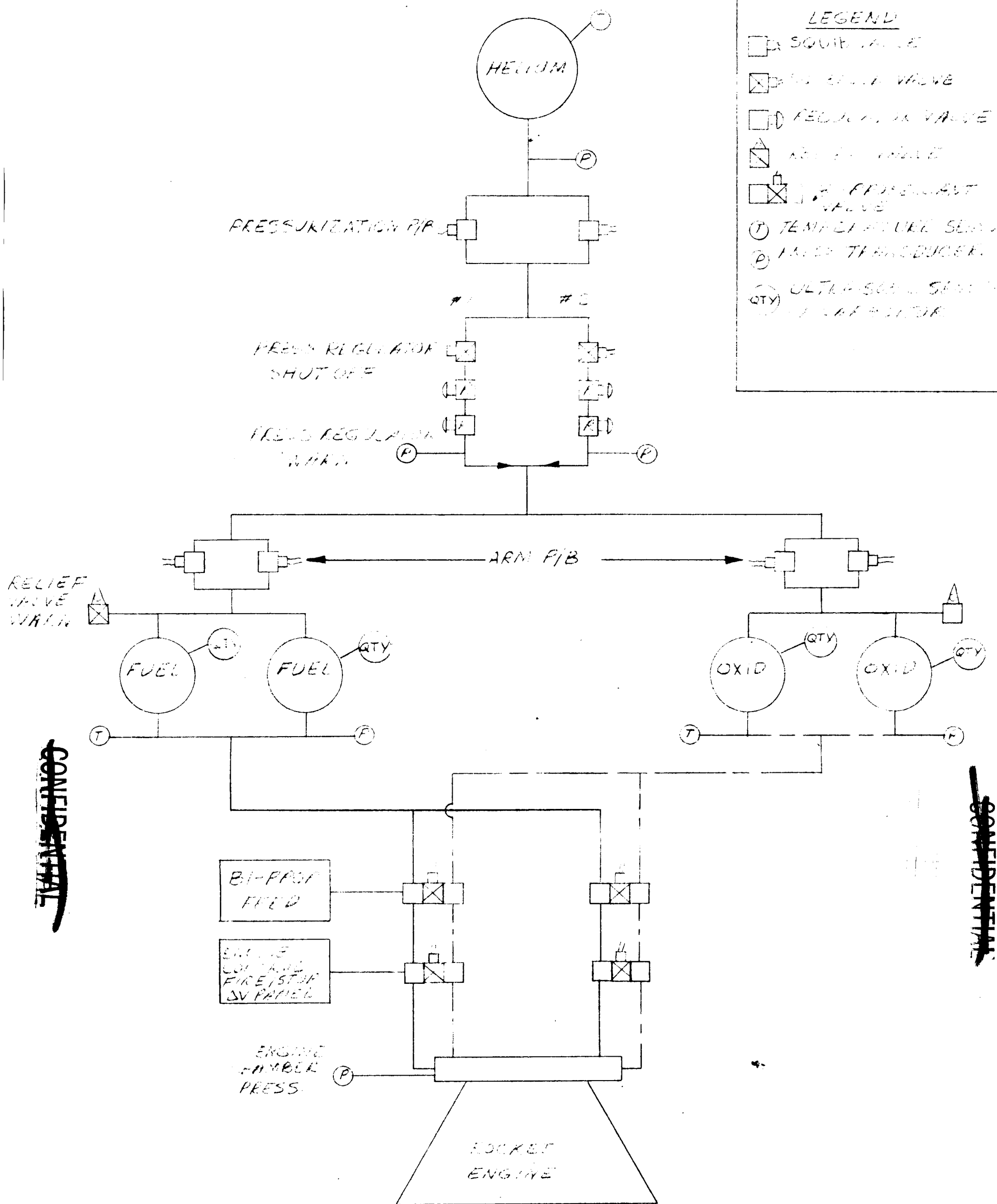
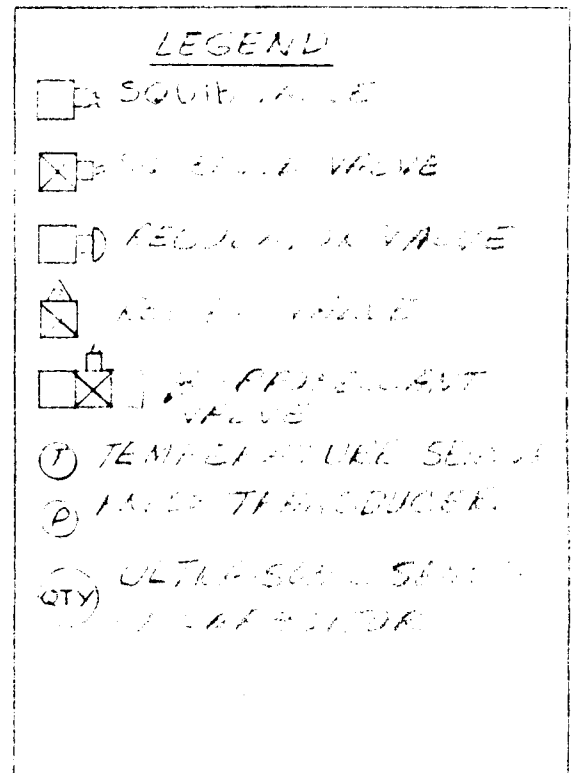
BI-PROPELLENT FEED

OPEN CLOSE

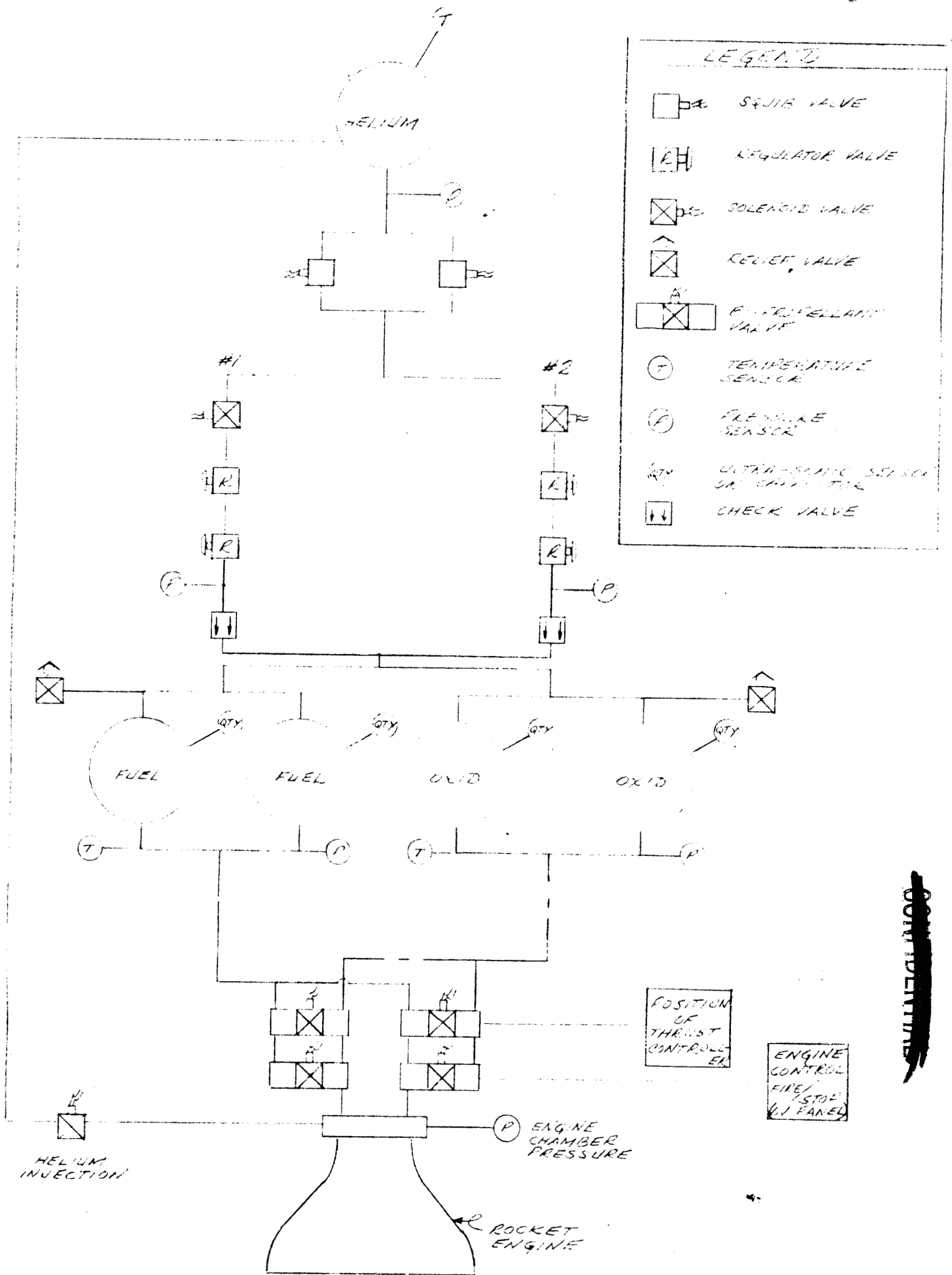
~~CONFIDENTIAL~~

LSR 480-1003

LEM ASCENT SCHEMATIC



LEM DESCENT SCHEMATIC



CONFIDENTIAL

CONFIDENTIAL

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
REACTION CONTROL SYSTEM SYSTEM "A" AND "B"	1. Pressurization Pushbutton (Guarded Switch) (1C)	Pre-Separation	Opens the squib valves downstream of the helium tanks in both System "A" and System "B". Since all valves downstream of the helium squib valves are normally open, igniting the helium squib valves will pressurize System "A" and "B" down to the thruster valves
	2. Fuel and Oxidizer Quantity Meter (1 Per System)	ALL	Monitors the Fuel and Oxidizer Quantity of each system. Two Meters required (One each for System "A" and "B").
	3. Fuel and Oxidizer Pressure Meter (1 per system)	ALL	Monitors the fuel and oxidizer pressure of each system. Two meters required for the RCS system (one each for System "A" and "B")
	4. Helium Pressure and Temperature Meter (1 per system)	ALL	Monitors the pressure and temperature in the helium tanks of each system. Two meters required (one each for System "A" and "B"). These meters permit the crew to determine the status of pressurization to the propellants.
	5. Pressure Regulator Warn Indicator Lights (4I)	ALL	If a pressure regulator malfunctions (pressure differential tolerance exceeded), the appropriate fail indicator light will illuminate, warning the crew of the failure and directing shutdown of the regulators. When the pressure regulator shutoff toggle is placed to the Off position, the fail light will extinguish.
	6. Relief Valve Warn Indicator Lights (4I)	ALL	If a pressure regulator malfunctions (pressure differential tolerance exceeded) the RELIEF VALVE WARN light will illuminate indicating helium vented overboard. The light will extinguish when the pressure is within tolerance limits. The RELIEF VALVE WARN light will remain illuminated if the relief valve remains open, in which case the PRESSURE REGULATOR SHUTOFF toggle for that leg is placed to the OFF position.
	7. Pressure Regulator (2 per system) (4C)	ALL	These latch-type solenoid valves (two each for System "A" and "B") are located upstream of the pressure regulators in each leg. The valves are normally in the open position. A pulse from the toggle switch will trigger the solenoid to the Off position.
	8. Propellant Feed Toggle Switch (1 per system)	ALL	Controls the flow of fuel and oxidizer (System "A" and System "B") downstream of the propellant tanks by means of solenoid valves. These valves are normally open, however, if a malfunction exists in one of the systems (either "A" or "B"), the malfunctioning system is shutdown by placing the PROPELLANT FEED toggle for that system to the CLOSE position.
	9. Cross-Tie Toggle Switch (1C)	Emergency	During normal operation System "A" and System "B" work simultaneously, each feeding 8 thrusters. However, if a malfunction exists in one of the systems, the malfunctioning system should be shut down by placing the PROPELLANT FEED toggle for that system (either "A" or "B") to the CLOSE position. The CROSS-TIE toggle should be placed to the OPEN position (opening the solenoid valves) permitting the operative system (either "A" or "B") to supply fuel and oxidizer to all 16 thrusters.
	10. Ascent Feed Toggle Switch (1C)	Emergency	Controls the fuel and oxidizer solenoid valves from the ascent tanks. In the event one of the RCS systems (either "A" or "B") malfunctions, the ascent tanks can supply the fuel and oxidizer to the 16 thrusters, while travelling in the + X direction during ascent phases. This can be accomplished by placing the ASCENT FEED toggle to the OPEN position and the PROPELLANT FEED toggle for the operative RCS system (either "A" or "B") to the CLOSE position. At the conclusion of X-axis thrusting, the PROPELLANT FEED toggle for the operative RCS system (either "A" or "B") is placed to the OPEN position and the ASCENT FEED toggle to the CLOSE position.

~~CONFIDENTIAL~~

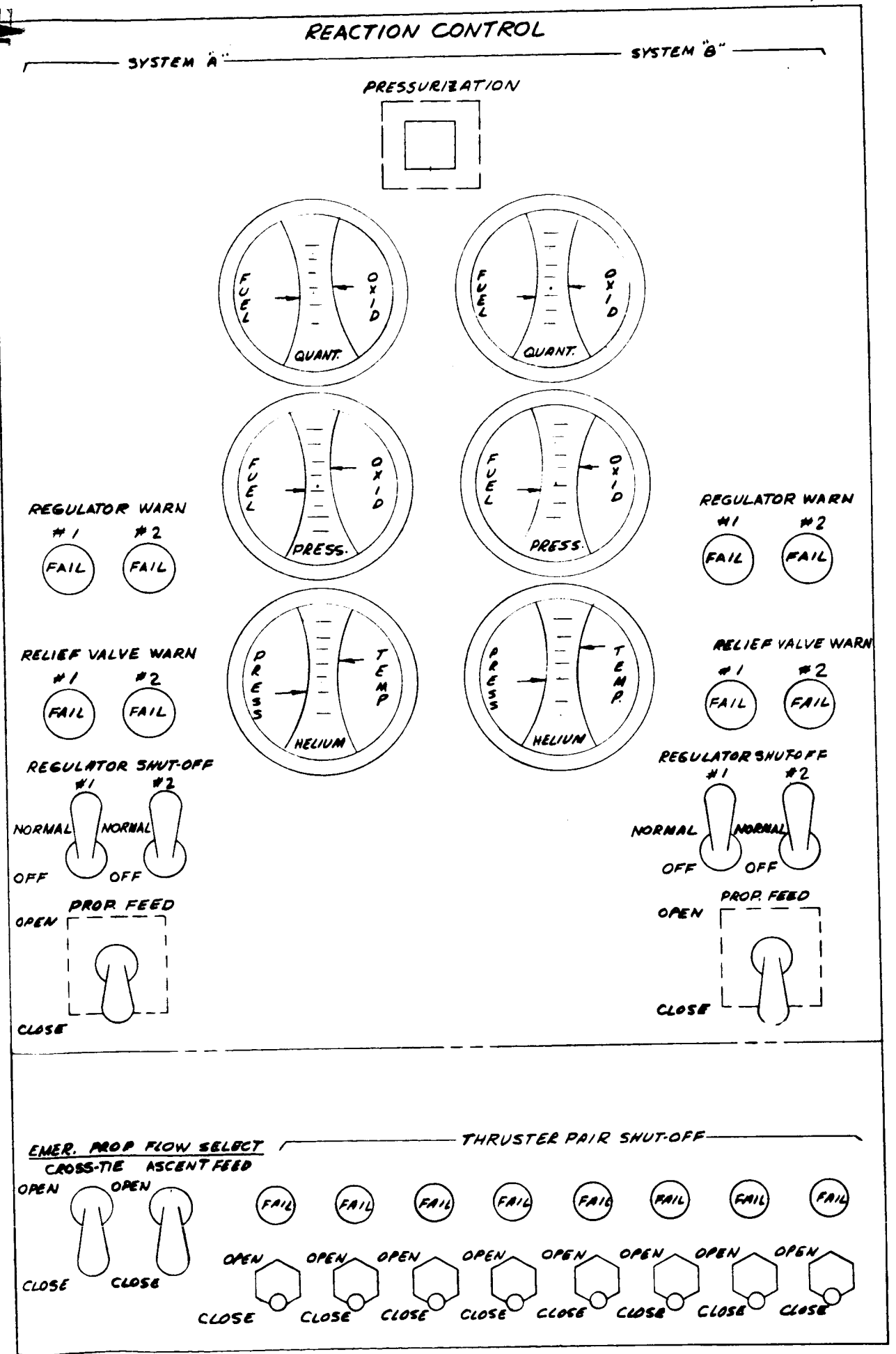
~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
REACTION CONTROL SYSTEM SYSTEM "A" AND SYSTEM "B"	11. Thruster Pair Shutoff Toggle Switches (8C)	Lunar Stay and Emergency	Each switch operates two solenoid valves controlling the fuel and oxidizer flow to a pair of thrusters. Eight toggles are required to control all thruster pairs. The valves (switches) are normally in the open position. They are manually closed during lunar stay shutdown and may be used for emergency shutdown during flight.
	12. Thruster Pair Fail Lights (8I)	Emergency	Each light when illuminated, indicates a failure of one or both thrusters in its associated pair. The crew will place the THRUSTER PAIR SHUTOFF toggle associated with the THRUSTER PAIR FAIL light to the CLOSE position, thus shutting down the malfunctioning pair and extinguishing the light.

~~CONFIDENTIAL~~

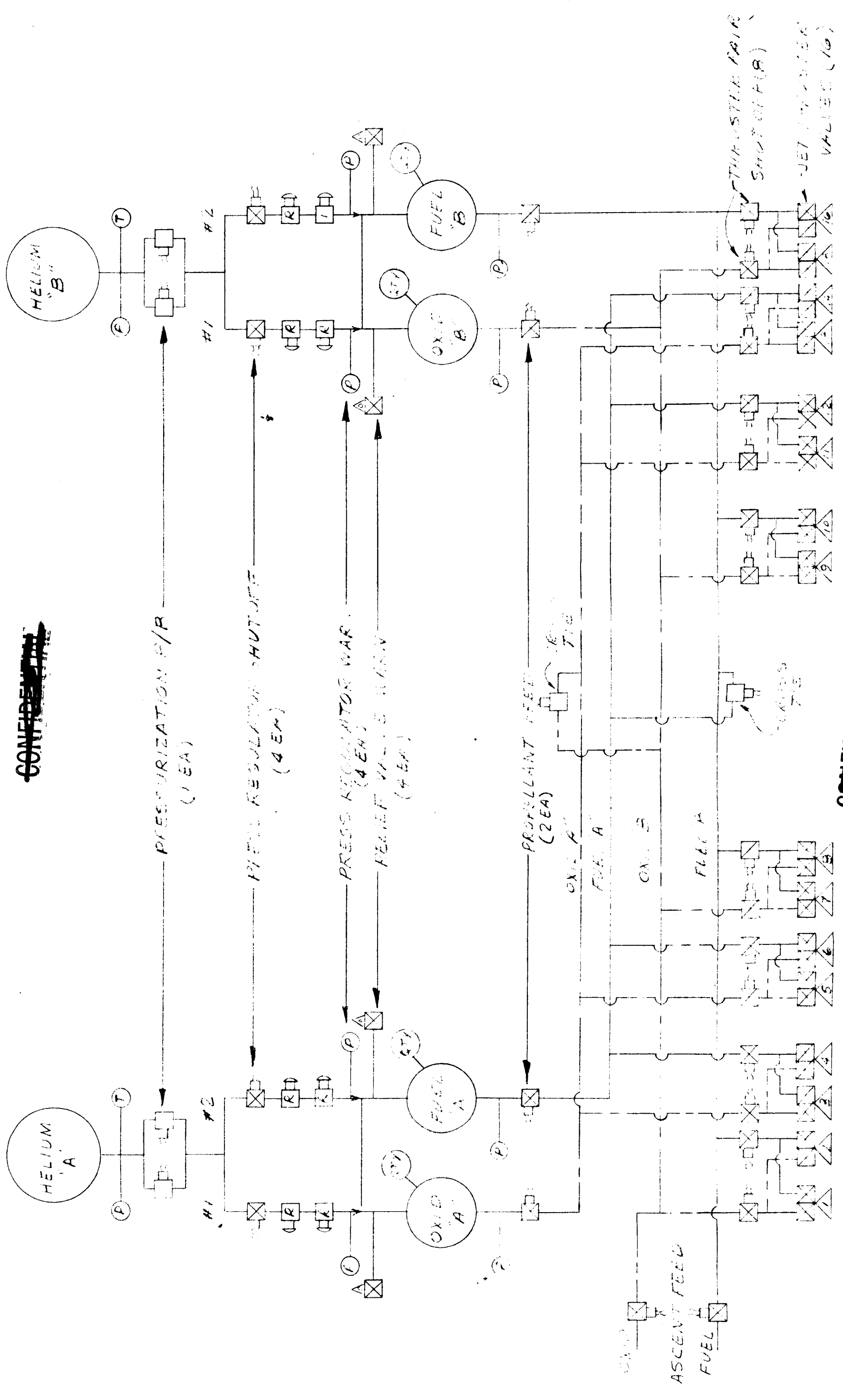
~~CONFIDENTIAL~~

10



~~CONFIDENTIAL~~

LEM RCS SCHEMATIC



~~CONFIDENTIAL~~

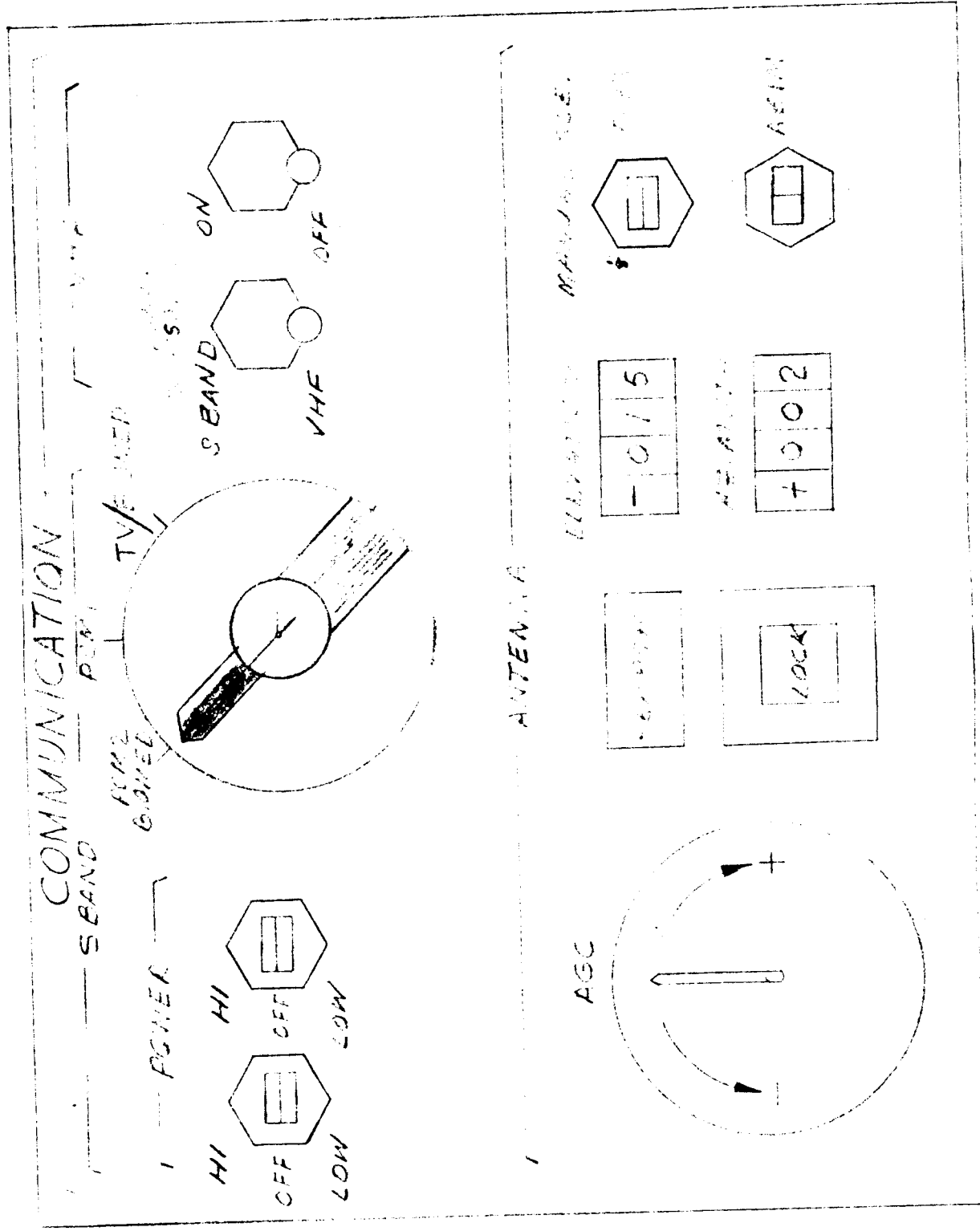
~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
COMMUNICATIONS	<u>S Band</u>		
	1. Power Switch	ALL	A three position switch (OFF, HI, LO) that under normal conditions will be operated in the HI position. In the HI position the transponder HI power amplifier is utilized. The backup mode is selected by placing the power switch in the LO position. If a second S band transponder is on board its use will be provided for in a similar manner through power switch 2.
	2. Mode Select Switch	ALL	Selects different spectrum utilization of the S band transponder band width. A three position switch with voice always present.
	<u>VHF</u>		
	3. Lunar Transmission Switch	Lunar Stay	A two position switch (S band-VHF) providing communications from the man on the lunar surface to the man in the LEM and to earth and Apollo. In the S Band position the transmissions from the lunar surface are detected in the LEM and transmitted to earth over the S Band transponder and to the APOLLO over VHF. In the VHF position the transmissions from the lunar surface are detected in the LEM and transmitted over VHF to APOLLO.
	4. Power Switch	ALL	A two position switch (ON-OFF) that applies power to the VHF transponder.
	<u>Antennas</u>		
	1. AGC meter	ALL	Indicates the degree of alignment of the 2 ft. dish antenna with its target. When the meter is peaked the antenna is aligned with the earth.
	2. Search Light	ALL	The search light illuminates whenever the dish is being driven by the automatic or manual search slewing mechanism.
	3. Search Activation	ALL	This push button switch will trigger an automatic search mechanism that will drive the two foot dish antenna through a pattern that will be a function of the beam width and the programmed area of coverage. When the target is encountered (the AGC meter will peak) the drive will be disengaged, and the AGC meter will provide an indication of how well the antenna is aligned with its target.
	Elevation Slew	ALL	Drives the two-foot antenna in the elevation axis. It overrides all automatic and lock-on slew features.
	Elevation Angle Readout	ALL	Indicates the elevation angle that the antenna is positioned
	Azimuth Slew	ALL	Drives the two-foot antenna in the azimuth axis. It overrides all automatic and lock-on slew features.
	Azimuth Angle Readout	ALL	Indicates the azimuth angle that the antenna is positioned.

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~



~~CONFIDENTIAL~~

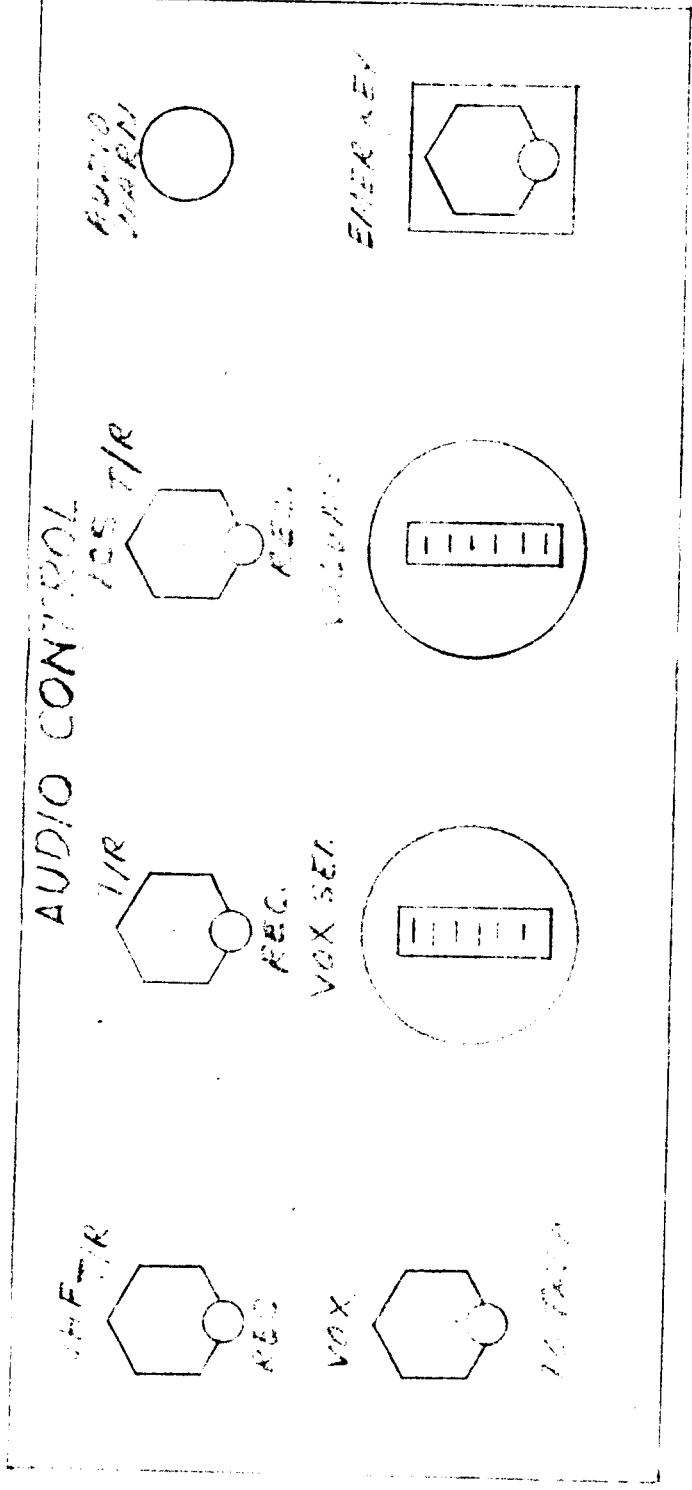
SAL GKECO
LSK 480-10004

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
AUDIO CONTROL	1. VHF Switch	All	A two position switch - one position for active utilization of the VHF transponder, the other for monitor of the VHF Receiver.
	2. S Band Switch	All	A two position switch - one position for active utilization of the S Band transponder, the other for monitor of the S Band Receiver.
	3. ICS Switch	All	A two position switch - one position for active utilization of the ICS system, the other for monitor of the ICS system.
	4. Audio Warn Switch	Emergency	A push button switch to shut off the emergency tone generated as a backup to some subsystem warning light
	5. VOX Switch	All	A two position switch (VOX - TO TALK). In the VOX position the mike is "hot" when one speaks. failure occurs in the VOX position, the switch must be positioned in the TO TALK position. The TO TALK position will provide manual keying of the mike.
	6. VOX Sen. Control	All	A thumb wheel control providing VOX sensitivity.
	7. Volume Control	All	A thumb wheel control providing Volume Control over the ICS preamp.
	8. Emergency Key	Emergency	A guarded switch that provides an emergency message when in the ON position.

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~



5AL GREGO LSK 4P 10010
4-12-63 AUDIO CONTROL

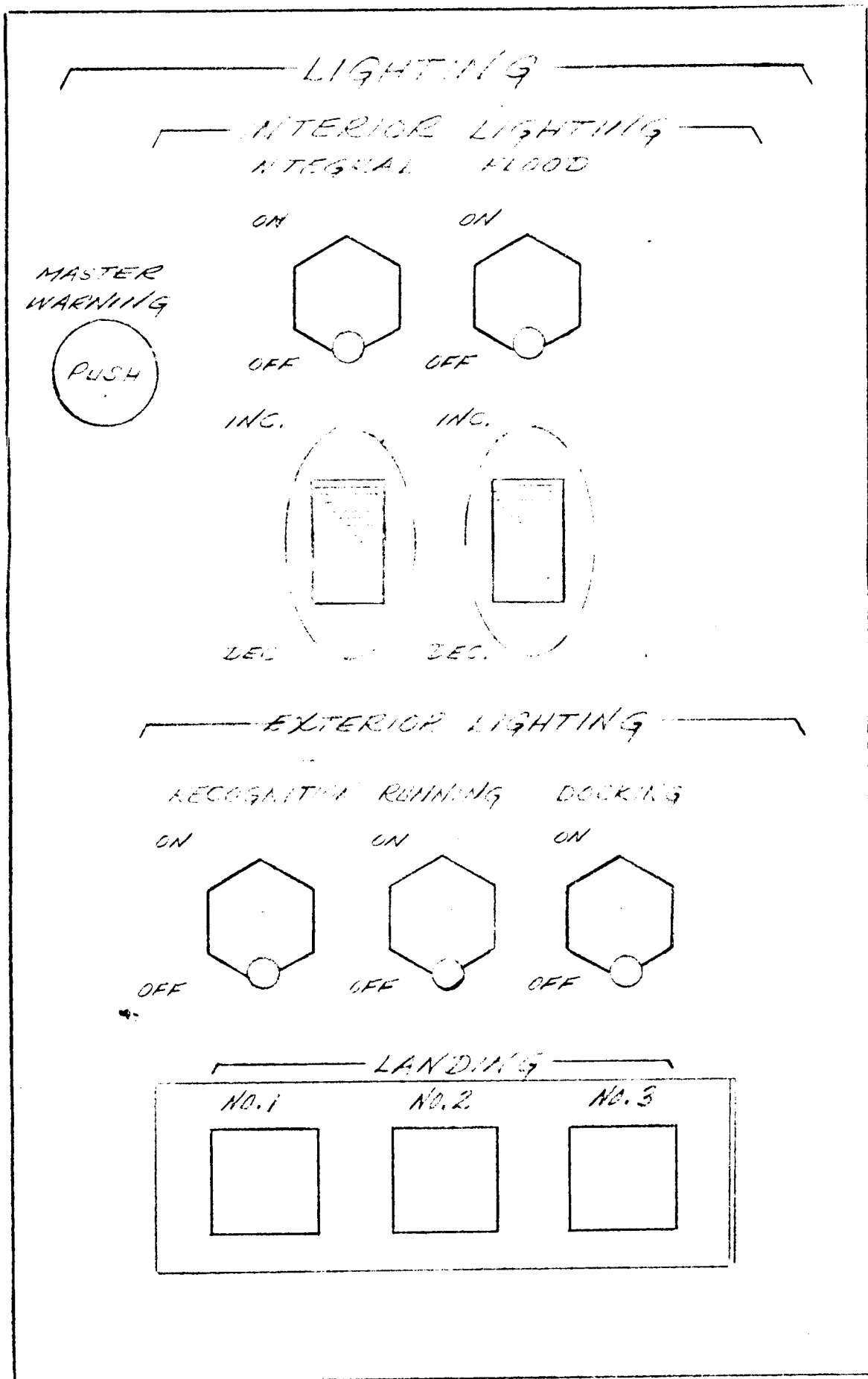
~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
LIGHTING	1. Interior Integral Switch	All darkness operation	This toggle switch turns on all instrument and panel integral lighting-used for normal operation.
	2. Interior integral dimming control	All darkness operation	The thumbwheel rheostat is used to vary the intensity of the integral lights.
	3. Interior Flood Lighting Switch	All darkness operation	The toggle switch turns on interior flood lighting which is a backup of the integral lighting - used only if integral lighting fails.
	4. Interior Flood Dimming Control	All darkness operation	The thumbwheel rheostat is used to vary the intensity of the flood lights.
	5. Master Warn, W6	All darkness operation	This pushbutton switch will light all master warning lights when depressed-used to test operation of lights.
	6. Exterior Recognition Light Switch	Docking	This switch turns on the blinking recognition light which is used in the event the command module has to dock with the LEM.(LEM passive and CM active)
	7. Exterior running light switch	Docking	This switch controls the running lights, a set pattern of lights which will enable the command module to determine the orientation of LEM as it approaches.
	8. Docking light switch	Docking	The docking lights are used when at close range to illuminate the docking ring and adjacent areas for Command Module docking to LEM.
	9. Landing light switches (3)	Landing	These (3) pushbuttons will release flares during the landing phase.

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~



~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
ENVIRONMENTAL CONTROL	1. Pressure, Cabin and Suit	ALL	Displays cabin and suit pressure. Inputs provided by pressure sensors respectively located in cabin and suit loops.
	2. Temperature, Cabin and Suit	ALL	Displays cabin and suit temperature. Inputs provided by temp. sensors respectively located in cabin and suit loops.
	3. SOX Quantity	ALL	Displays SOX quantity remaining. Located in SOX tank.
	4. SOX Pressure	ALL	Displays SOX pressure in the SOX line.
	5. H ₂ O Quantity	ALL	Displays total water remaining on the vehicle.
	6. Glycol Pressure	ALL	Displays Glycol coolant pressure
	7. CO ₂ Partial Pressure	ALL	Displays CO ₂ partial pressure in the cabin and suit loops
	8. Suit Fan Lights	Emergency	Indicates failure of any one of the 3 suit fans. 3 lights, 1 light for each fan.
	9. Glycol Pump Lights	Emergency	Indicates failure of any one of the 3 glycol pumps. A total of 3 lights 1 light for each pump.
	10. LIOH Lights	Approx. Every 4 Hours	Indicates failure of any one of 2 LIOH cannisters. A total of 2 lights - 1 light for each cannister. Light will come on when cannisters saturation point is approached. Cannister should then be replaced with a spare.
	11. H ₂ O Separator Lights	Emergency	Indicates failure of one of the two water separators. One light for each water separator. Must switch over to remaining H ₂ O separator.
	12. Glycol Temperature	Emergency	Indicates glycol temperature condition if it exceeds normal limits.
	13. O ₂ Inflow Controls	ALL and Emergency	2 switches positioned normally in the automatic mode. In this mode the pressure sensors controlling the valves are as selected by the pressure select switch. These valves are in parallel and only one is activated at any one time. If one valve fails there is an automatic switch over to the other valve. A warning light will indicate the failed valve.. If the second valve fails a manual over-ride will maintain cabin pressure. This will be provided by the same switches now placed in the open position. In this position a momentary switch is used which will pulse the valve open for as long as is necessary to build up cabin pressure. This requires holding the switch to the open position until the desired cabin pressure is reached.
	14. Pressure Select	ALL and Emergency	A single 3 position switch which selects the pressure sensors that will control the O ₂ in-flow valves. The normal mode of operation will be the automatic mode. In this mode the 5 PSI and 3.5 PSI sensors will control the valve. In the 5 position only the 5 PSI sensor controls the valve and in the 3.5 position only the 3.5 PSI sensor controls the valve.
	15. O ₂ Flood Switch	Pressurization of Cabin and Emergency Repressurization	A 2 position switch whose normal position will be the automatic position. In case of a rapid decompression, this O ₂ flow valve will open and repressurize the cabin. It will bypass the O ₂ inflow valves. In the manual position can selectively pressurize the cabin.
	16. O ₂ Flood Light	Pressurization of Cabin and Emergency	When pressurizing cabin, light remains lit as long as O ₂ flood switch remains in the manual position

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL INDICATOR	MISSION PHASE	FUNCTION
ENVIRONMENTAL CONTROL (CON'D)	17. Cabin Temp. Control	ALL	Selectively sets cabin temperature - a vernier control.
	18. Cabin Fan Toggle	Where Needed	An on-off switch that provides for recirculation of cabin air when the fan is turned on.
	19. Suit Emergency Boiler Switch	Over Heat Condition Emergency	A single switch that when in the on position activates the emergency boiler providing for the rejection of suit waste heat when heat rejection by the suit circuit heat exchanger is inadequate.
	20. Suit Fan Switch	ALL and Emergency	A 3 position switch that selects any one of 3 parallel fans for O ₂ recirculation. Only one fan is in operation at any one time.
	21. SOX Separate Switch	Emergency	A guarded toggle switch when thrown provides SOX line separation and isolation of the O ₂ accumulator. This is a backup to an automatic process that should occur during abort or ascent from the lunar surface.
	22. SOX Heater switch and SOX Heater light	ALL and Emergency	A 2 position switch normally in the automatic position. In the automatic position a heater provides the correct pressure in the SOX tank. In the heat position the SOX is heated for as long a period of time as this switch position is maintained. SOX Heater light is illuminated when switch is in the manual heat position.
	23. Glycol Pressure Mode Select	ALL, Test and Emergency	A 2 position switch designed to test and or provide a backup means of selecting any one of 3 glycol pumps already selected by the glycol pump select switch as well as a means of selecting the glycol pumps automatically in case of pump failure.
	24. Glycol Pump Select Switch	ALL, Test and Emergency	A 3 position switch that selects any one of the 3 glycol pumps for test or for a backup select in case of an automatic pump switching failure.
CENTER OVER-HEAD PANEL	25. Manual O ₂ In Flow Valves (2)	Emergency	Manual control of the O ₂ inflow to the suit circuit. A manual means of maintaining suit pressure or cabin pressure in case of automatic valve actuation failure.
	1. Diverter Valve	ALL and Emergency	A valve which closes automatically to provide suit circuit integrity during cabin decompression. This valve must be manually opened. In the open position the entire gas flow of the suit circuit is passed downstream of the space suit disconnects into the cabin.
	2. Cabin Gas Return Valve	ALL and Emergency	This valve is installed in the duct returning cabin gas to the suit circuit. It is automatically controlled to prevent the loss of suit circuit gas in the event of cabin decompression.
	3. Suit Circuit Relief Valve	Emergency	Prevents the overpressurization of the space suit.

~~CONFIDENTIAL~~

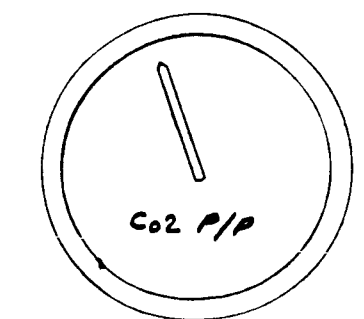
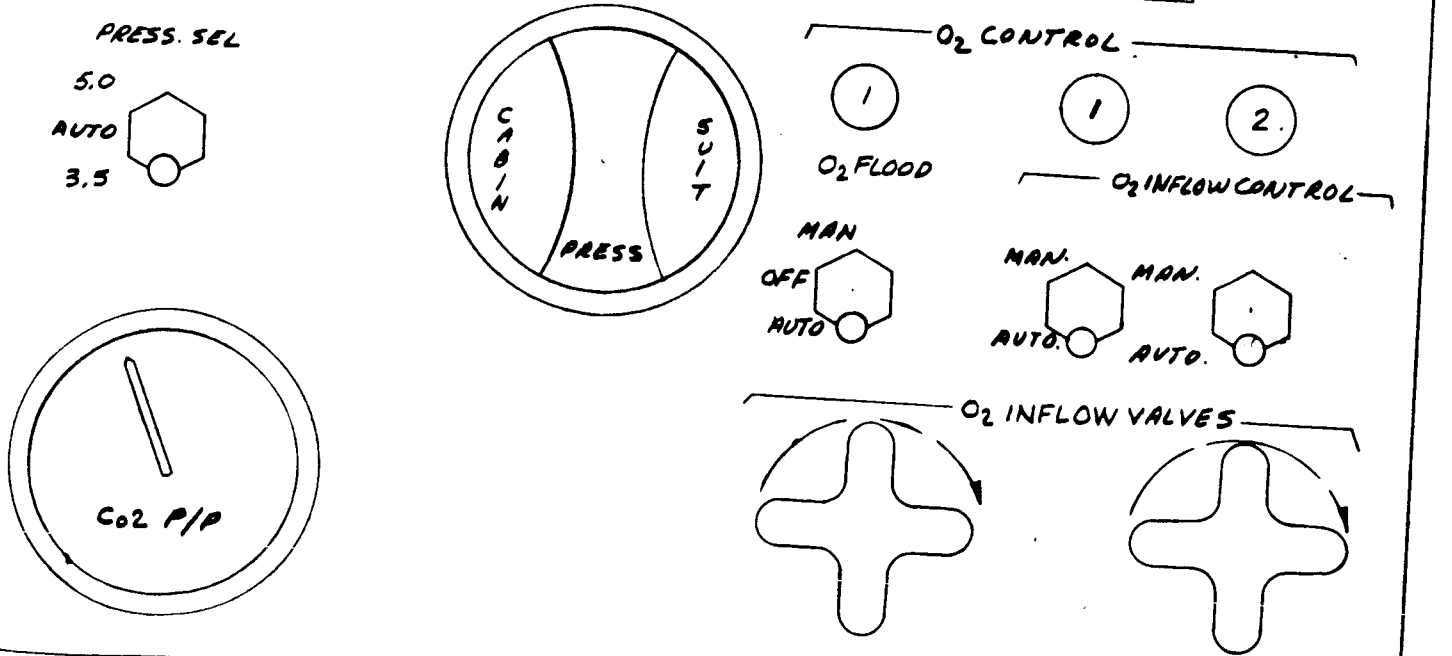
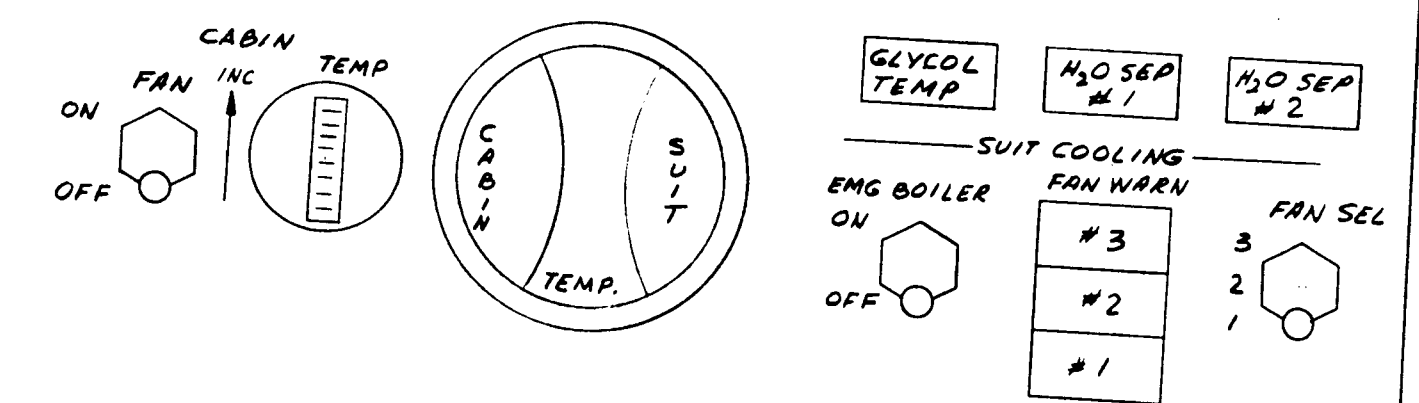
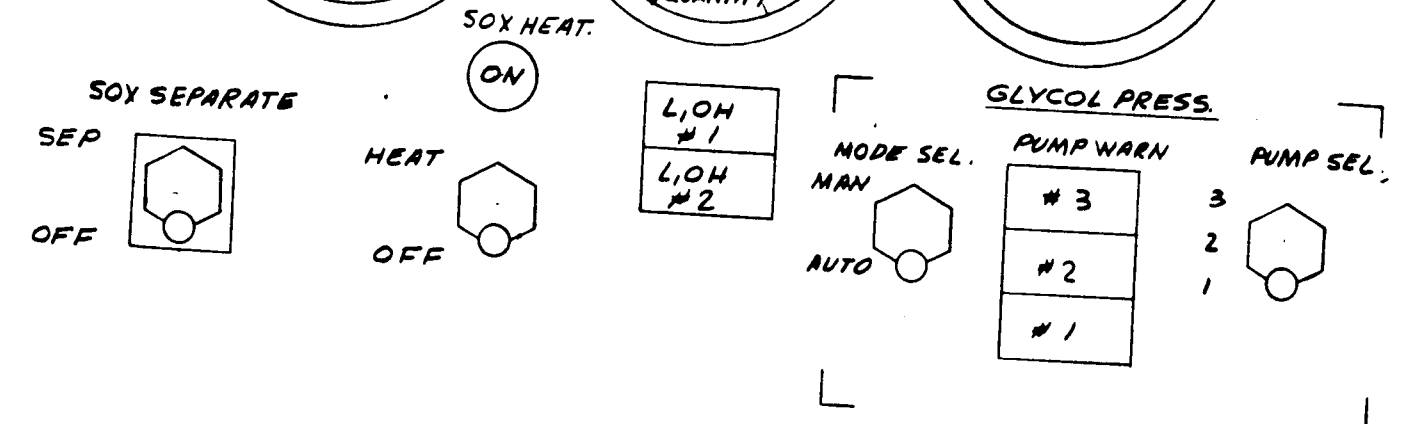
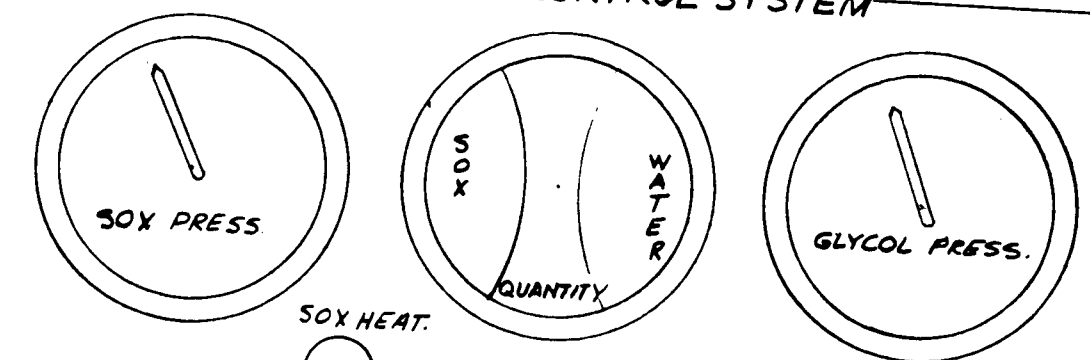
~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
ENVIRONMENTAL CONTROL (AUX. PANEL)	1. LIOH Select Valve	ALL	A 2 position valve that selects 1 of 2 LIOH cannisters for filtering the CO ₂ in the suit and cabin circuits.
	2. Water Separator Select Valve	ALL	A 2 position valve that selects 1 of 2 water separators for use in the cabin and suit circuits.
	3. Cabin Temperature Valve	EMERGENCY	Manual control of temperature of the coolant supplied to the cabin heat exchanger. A back-up for the cabin temperature controller that is on the front panel.
	4. SOX Shut Off Valve	SEPARATION OR ABORT	Isolates SOX storage tank from the system.
	5. Coolant Shut Off Valves	EMERGENCY	Permits isolation of the coolant accumulator and the coolant reservoir from the remainder of the heat transport loop.
	6. Water Shut Off Valves	EMERGENCY	Controls the flow of water from the water tank to the suit circuit water evaporator, the coolant water evaporator and the PLSS water disconnect.
	7. Manual O ₂ Shutoff Valve	Emergency Mode	Provides for control over PLSS quick disconnect if quick disconnect fails open.
	8.. Manual O ₂ Flood Valves	Emergency	Provides cabin pressurization manually.
	9. Manual Cabin Dump		Cabin depressurization

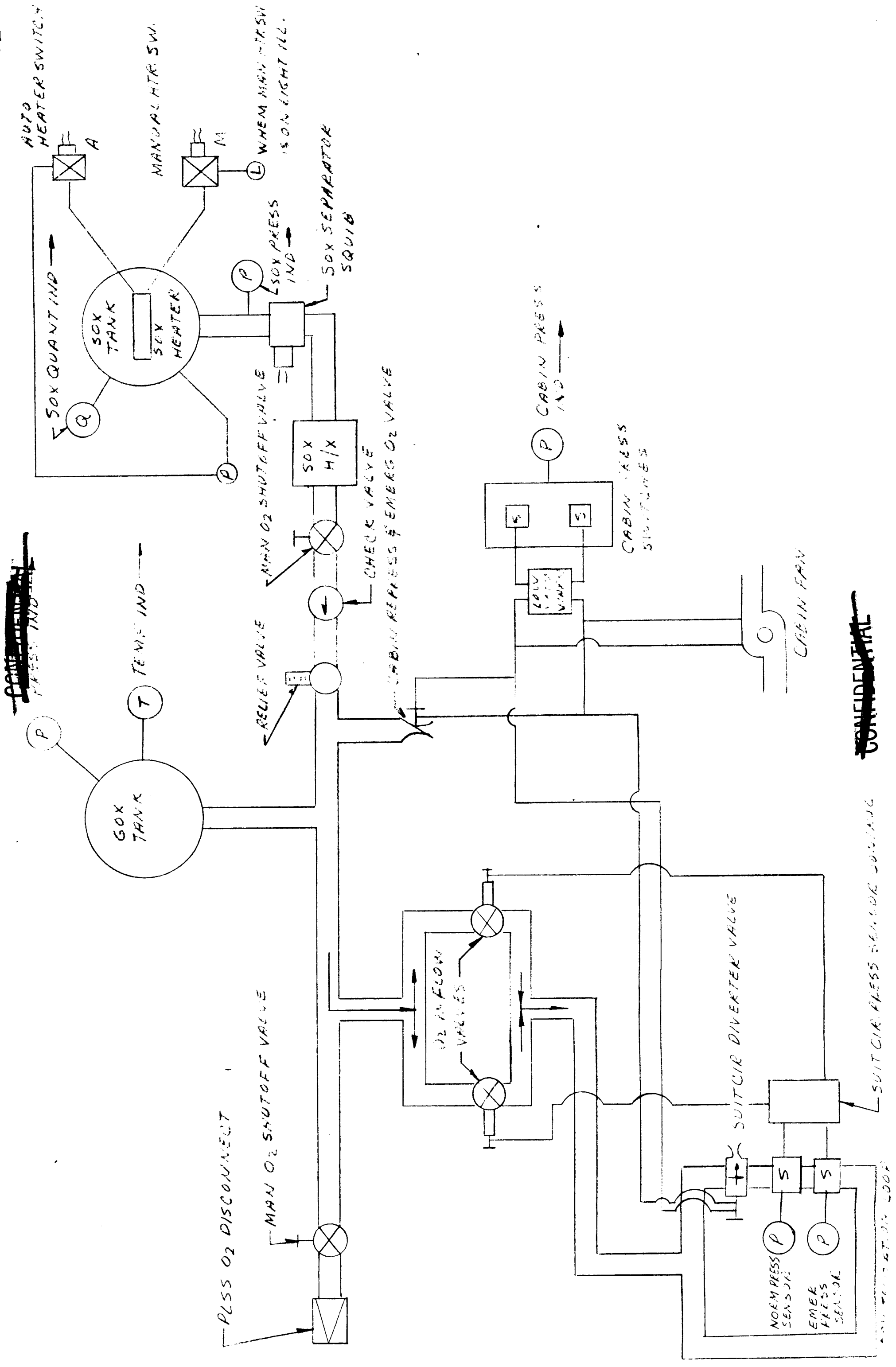
~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

ENVIRONMENTAL CONTROL SYSTEM

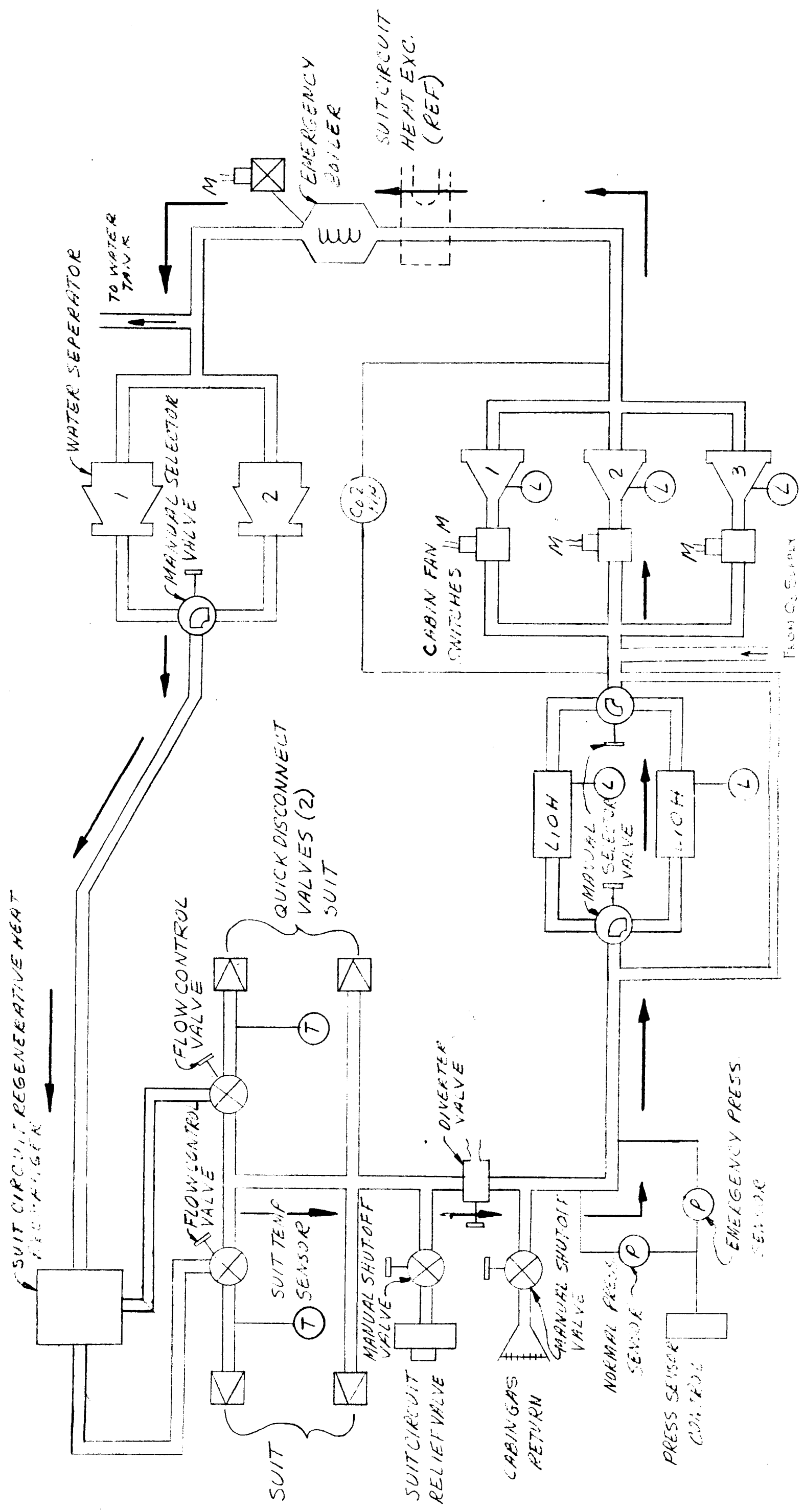


~~CONFIDENTIAL~~

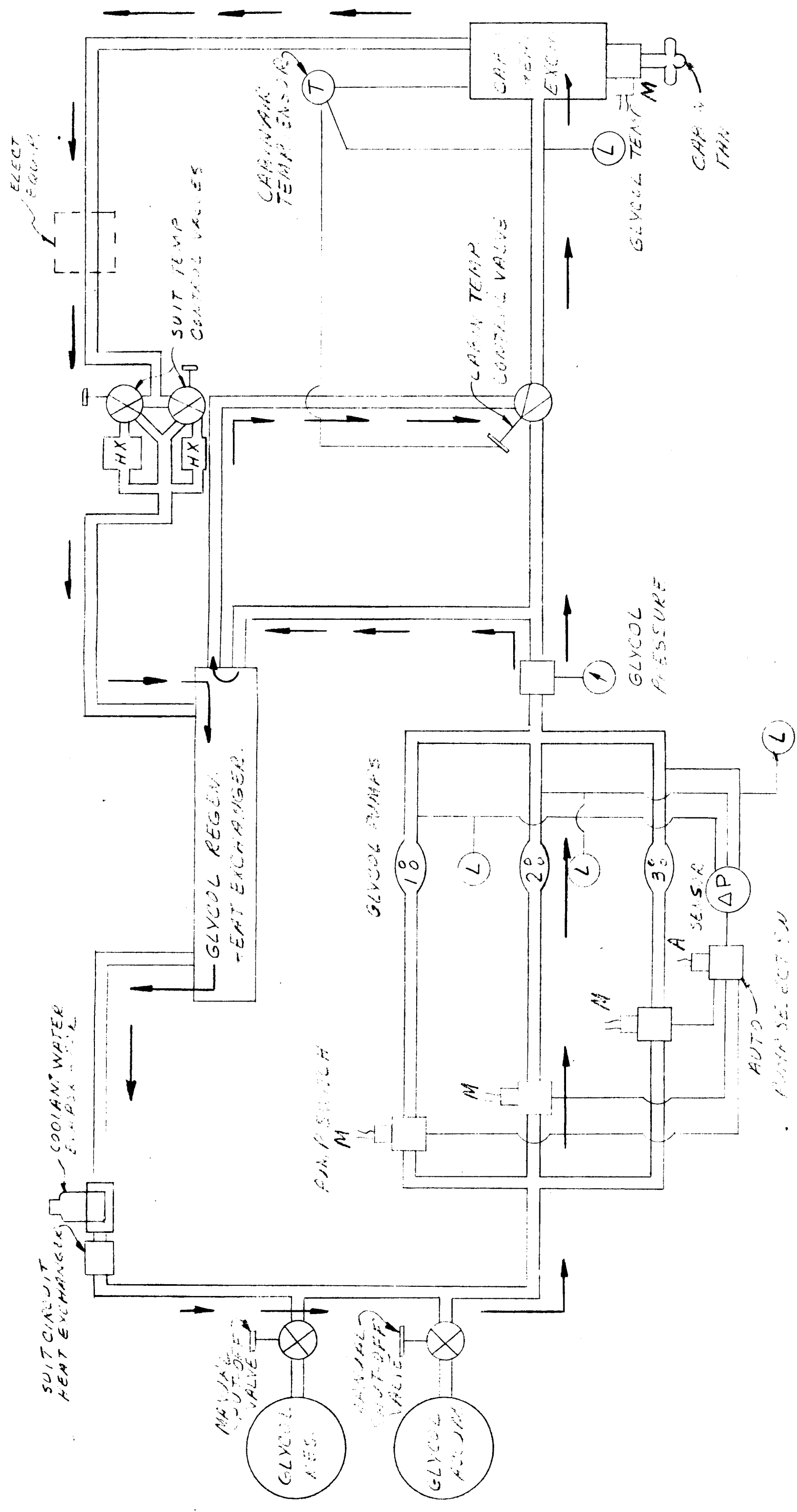


~~CONFIDENTIAL~~

SUITCIR PRESS SENSING CIRCUIT



~~CONFIDENTIAL~~

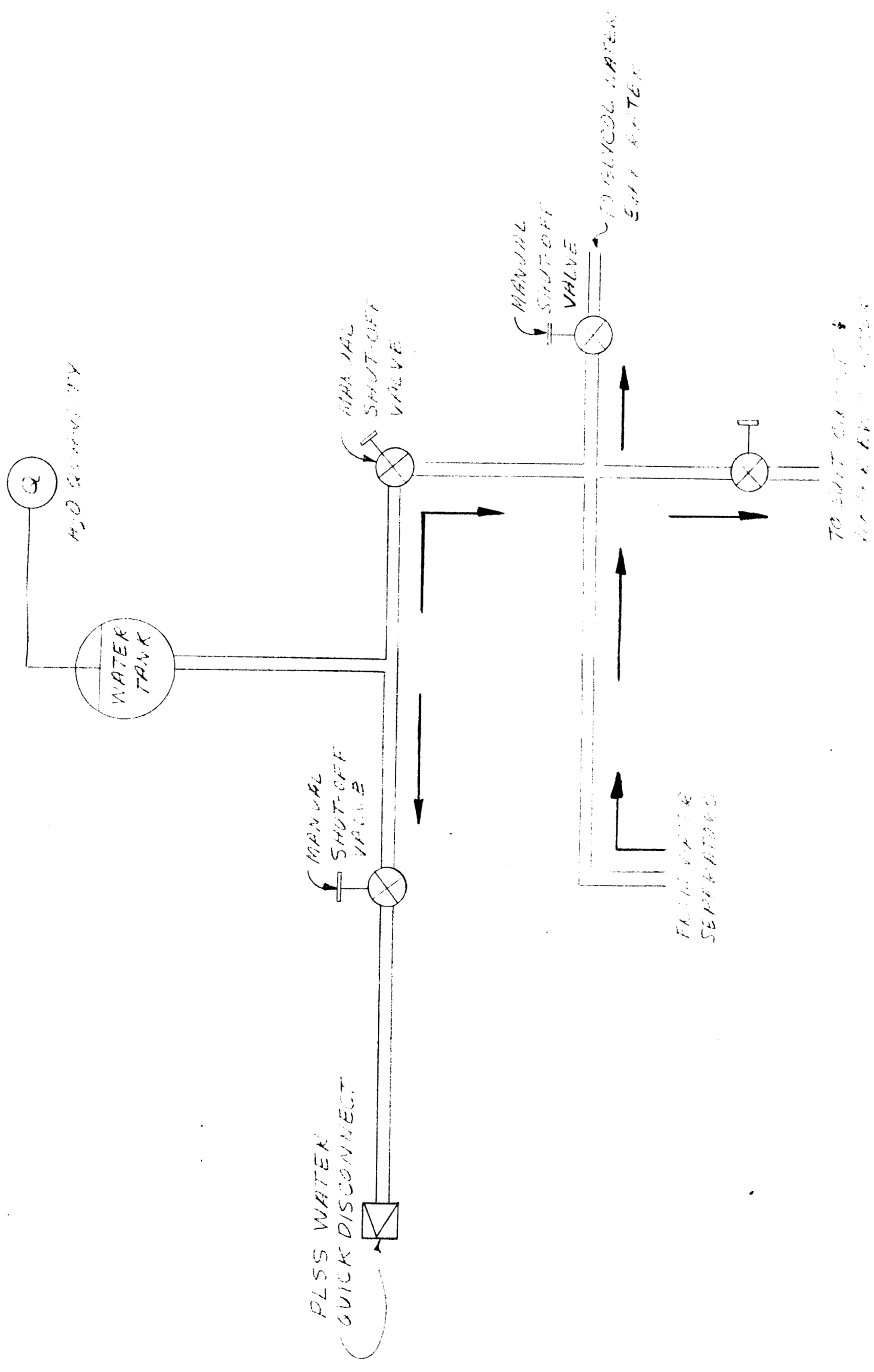


ECS ~ HEAT TRANSPORT SYSTEM

~~CONFIDENTIAL~~

ECS - WATER MANAGEMENT SYSTEM

~~CONFIDENTIAL~~



~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
RADAR	<u>RENDEZVOUS RADAR</u>		
	1. Power ON-OFF Switch	Rendezvous	Applies power to the rendezvous radar. A 2 position switch ON-OFF.
	2. Antenna Elevation Indicator	Rendezvous	Indicates the elevation angle of the radar antenna with respect to a fixed coordinate system.
	3. Antenna Azimuth Indicator	Rendezvous	Indicates the azimuth angle of the radar antenna with respect to a fixed coordinate system.
	4. Antenna Elevation Slew	Rendezvous	A manual control of the radar antenna along the elevation axis.
	5. Antenna Azimuth slew	Rendezvous	A manual control of the radar antenna along the azimuth axis.
	6. Mode Select Switch	Rendezvous	A two position switch(auto-manual) that provides for automatic search and tracking of the Command Module in the auto position and a manual search mode in the manual position.
	7. SCT TIE	Rendezvous	A two position switch labeled"engage-disengage". In the engage position the radar antenna is slewed to alignment with the scanning telescope by commanded inputs from the scanning telescope servos. In the disengage position the radar is controlled by the mode select switch.
	<u>RADAR ALTIMETER</u>		
	1. Power Switch ON-OFF	Descent	A two position switch that applies power to the radar altimeter.
	2. Mode Select Switch	Descent	A two position switch (Descent-Hover) that dictates the radar altimeter's antenna position with respect to the vehicle's X axis.

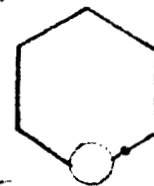
~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

RADAR

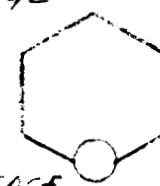
RENDEZVOUS RADAR
POWER OMU TIE

ON



OFF

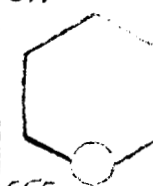
ENGAGE



DISENGAGE

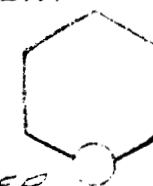
RADAR ALTIMETER
POWER MODE

ON



OFF

DESCENT

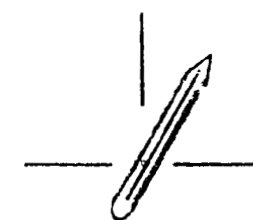


HOVER

ANTENNA SLEW



ELEV.

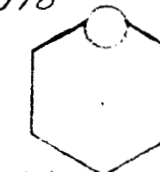


AZ.

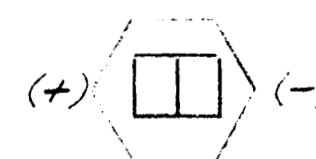


MODE

AUTO



MANUAL

~~CONFIDENTIAL~~

LSK 482-10057

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
POWER DISTRIBUTION (AC POWER)	1. Voltmeter	ALL	Monitors voltage of one selected phase of AC power from the AC bus
	2. Frequency Meter	ALL	Monitor frequency of one selected phase of AC power from the AC bus
	3. Phase Select Switch	ALL	Selects the Phase (A, B, C) which the voltmeter and frequency meter will monitor.
	4. Inverter Temperature Lights	ALL	3 lights, one for each inverter. If an overheat condition occurs in any inverter corresponding light goes on.
	5. Inverter Select Switch	ALL	Applies power to inverter selected.
	6. Battery Charger Switch	ALL	Selects Battery ("A" or "B") to be charged.
	7. Phase Failure Lights (3)	EMERGENCY	A phase failure or voltage failure will trigger light.
	8. Phase Control Switches (3)	ALL	Turn single phase loadsoff or on to selected inverter phases.
	9. (DC Power) Voltmeter	ALL	Monitor DC voltage of selected source
	10. Voltmeter Select Switch	ALL	Selects source of DC power to monitor voltage. Positions are: Fuel Cell 1, 2, 3; Bus A and B, Batteries A, B and Pyro
	11. Ammeter	ALL	Monitor current in-line selected.
	12. Ammeter Select Switch	ALL	Selects line to monitor current from fuel cell 1, 2, 3 or total current flow from Bus "A" and Bus "B".
	13. Bus "A" and "B" Input Switches (6)	ALL	Connects fuel cell 1, 2 or 3 to Bus "A". Same for Bus "B" switch.
	14. Bus Under Voltage Lights (2)	ALL	The light will come on when the voltage on the indicated bus drops below a certain level.
	15. Bus Tie Switches (3)	ALL	Connects essential loads to Bus "A" and/or Bus "B" and non-essential loads to Bus "A" or Bus "B".

~~CONFIDENTIAL~~

~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL INDICATOR	MISSION PHASE	FUNCTION
ELECTRIC POWER	1. O ₂ Flow Control: (2) Toggles	ALL	Controls the out flow of O ₂ from the two oxygen storage tanks each control gives full open or shutoff signals to one solenoid valve.
	2. H ₂ Flow Control: (2) Toggles	ALL	Controls the out flow of H ₂ from the two hydrogen storage tanks, each control gives full open or shutoff signals to one solenoid valve.
	3. O ₂ Heater Control (2)	ALL	These three position switches (off-auto-manual override) control the heating requirements of the two oxygen tanks. In the auto position (normal mode) the heater cuts-in automatically to maintain the O ₂ pressure within a fixed range. However, if a malfunction occurs, the operator can manually override the automatic control and apply heat until the desired pressure is obtained. Due to the nature of this manual operation (danger in over pressurizing) an associated light will glow whenever you are in the manual position. In the off position the thermal loop is opened and no power is expended.
	4. H ₂ Heater Control (2)	ALL	Same as O ₂ heater control, except these control the heating of the hydrogen tanks.
	5. H ₂ Pressure	ALL	Displays the tank pressure in the Hydrogen tanks number 1 and 2.
	6. O ₂ Pressure	ALL	Displays the tank pressure in the oxygen tanks number 1 and 2.
	7. H ₂ Quantity	ALL	Displays the tank quantity in the hydrogen tanks number 1 and 2.
	8. O ₂ Quantity	ALL	Displays the tank quantity in the oxygen tanks number 1 and 2.
	9. Fuel Cell Flow (3)	ALL	Controls the reactants flow (hydrogen-oxygen) to each fuel cell (number 1, 2 and 3)
	10. Fuel Cell Heater Control (3)	ALL	These three position switches (off-auto-manual override) control the heating requirements of the fuel cells. Each cell has its own control. In the auto position (normal mode) the heaters cut-in and out automatically to maintain the temperature of the cell within a set range. However if malfunctioning the operator can manually override the automatic control and apply heat until the desired temperature is obtained. Due to the nature of the manual operation, an associated light will glow whenever you are in the manual position. In the off position the thermal loop is opened and no power is expended.
	11. H ₂ Vent (3)	ALL	These two position switches (open-close), one for each fuel cell, will control the cooling and water removal functions for the fuel cells.
	12. O ₂ Purge (3)	ALL	These three position switches, one for each fuel cell, will purify the individual cells. In the auto position (normal mode) the fuel cell systems will be purged approximately every four hours. However, if the automatic purge doesn't operate properly - and a cell becomes contaminated (voltage drops) - the operator can manually purge. Since overactivation of this manual control could deplete your fuel cell system of O ₂ , a light will glow when the switch is in the manual position.
	13. H ₂ - O ₂ Pressure Indicator	ALL	Indicates the pressure of the hydrogen and oxygen past the H ₂ and O ₂ regulators.

~~CONFIDENTIAL~~

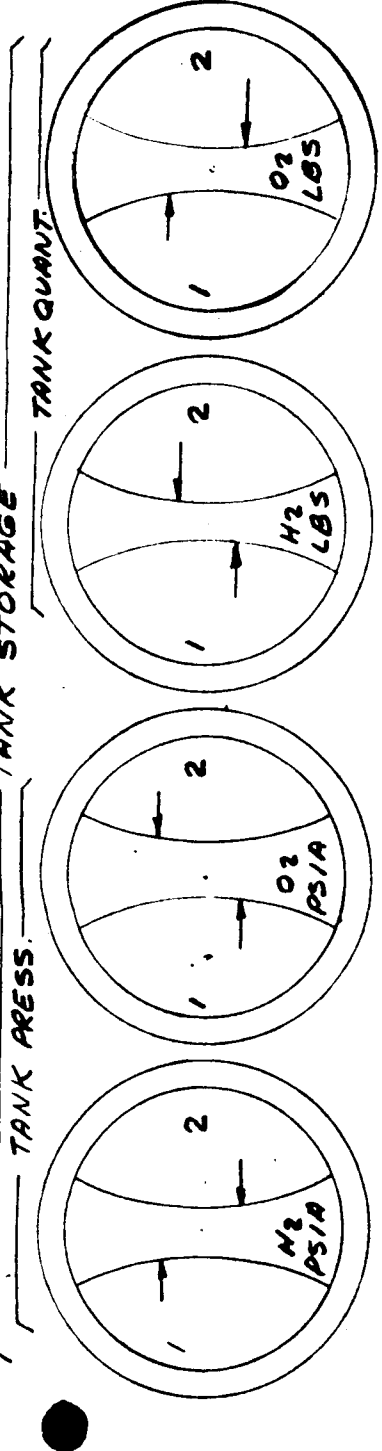
~~CONFIDENTIAL~~

SUBSYSTEM	CONTROL/INDICATOR	MISSION PHASE	FUNCTION
ELECTRIC POWER (CONT'D)	14. N ₂ Pressure Fail Lights	Emergency	3 lights, 1 for each fuel cell. If lights go on the tolerable pressure limits of N ₂ have been exceeded. The N ₂ of this system establishes the pressure reference for the H ₂ -O ₂ regulators. If N ₂ pressure fail lights come on must shutdown corresponding regulator.
	15. Fuel Cell Temp. Indicator	ALL	Indicates fuel cell temperature.
	16. Indicator Select	ALL	Selects the fuel cell and parameters to be displayed concerning fuel cell such as (H ₂ -O ₂ PSI and Fuel Cell Temperature.

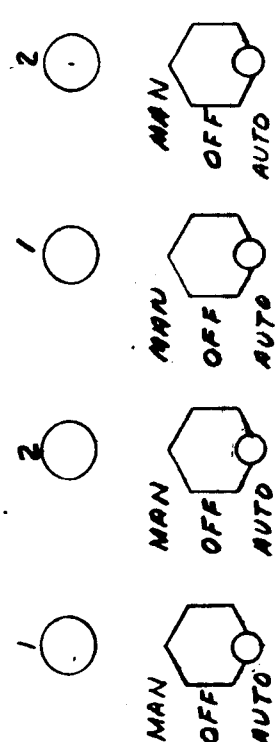
~~CONFIDENTIAL~~

POWER GENERATION

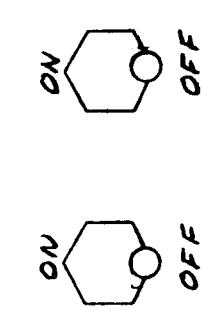
TANK STORAGE



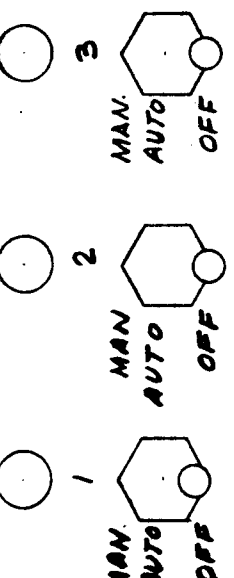
H2 HEATERS



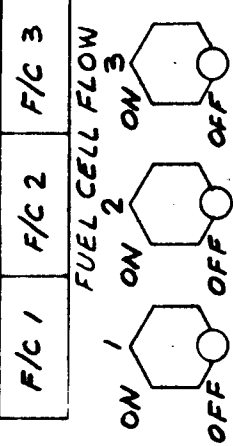
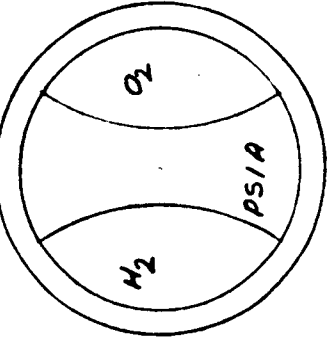
H2 FLOW



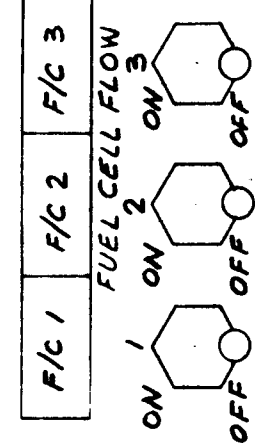
FUEL CELL HEATERS



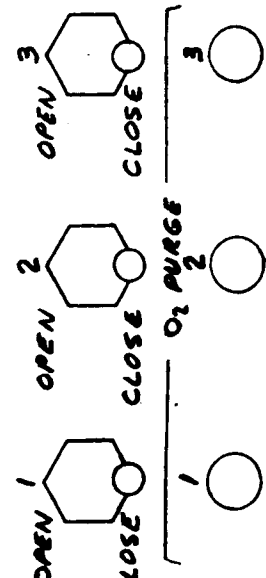
FUEL CELL PRESS.



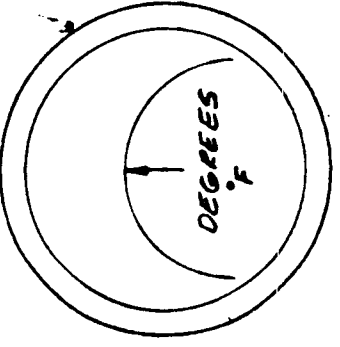
N2 FAIL



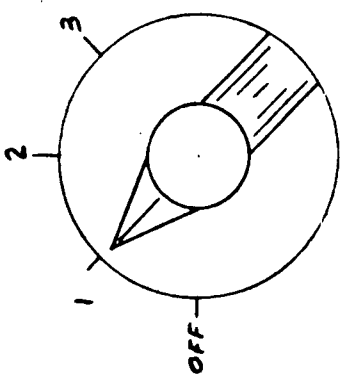
H2 VENTS



FUEL CELL TEMP.

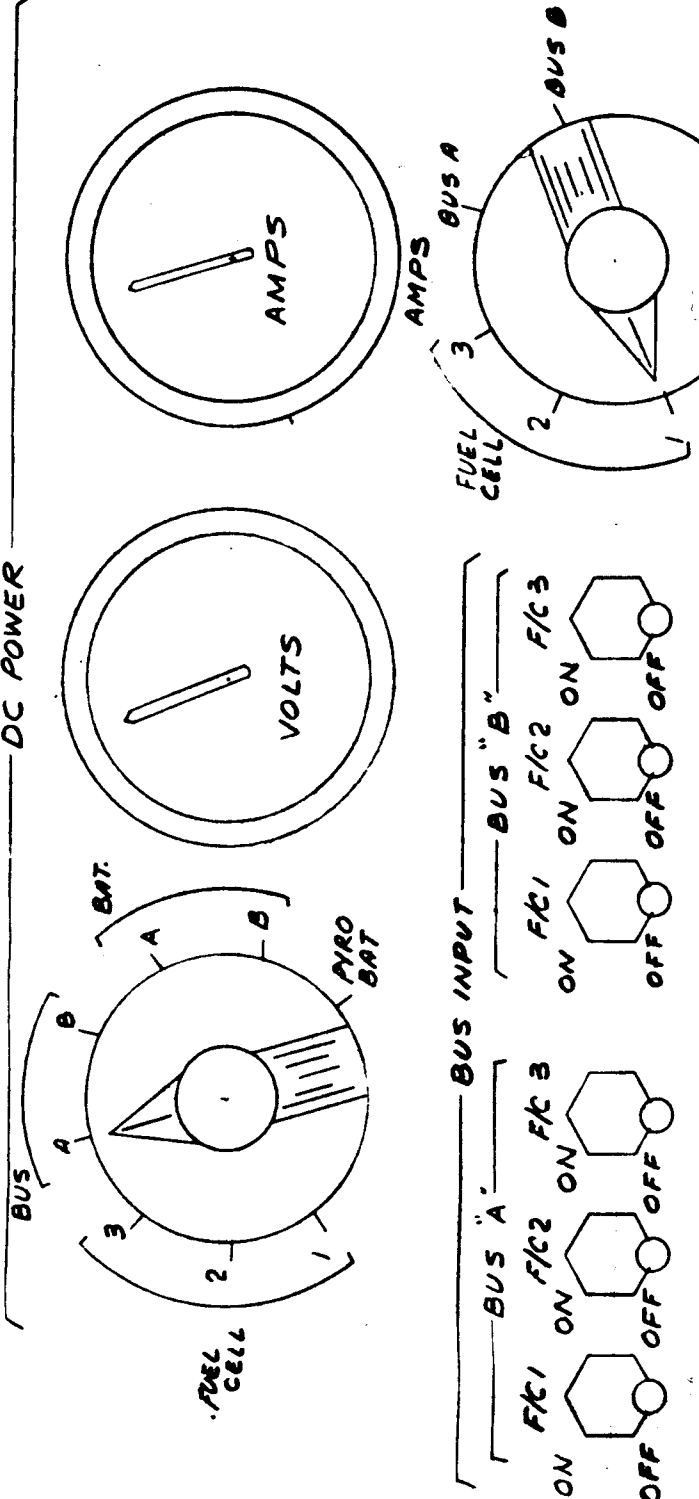


FUEL CELL MONITOR SEL.

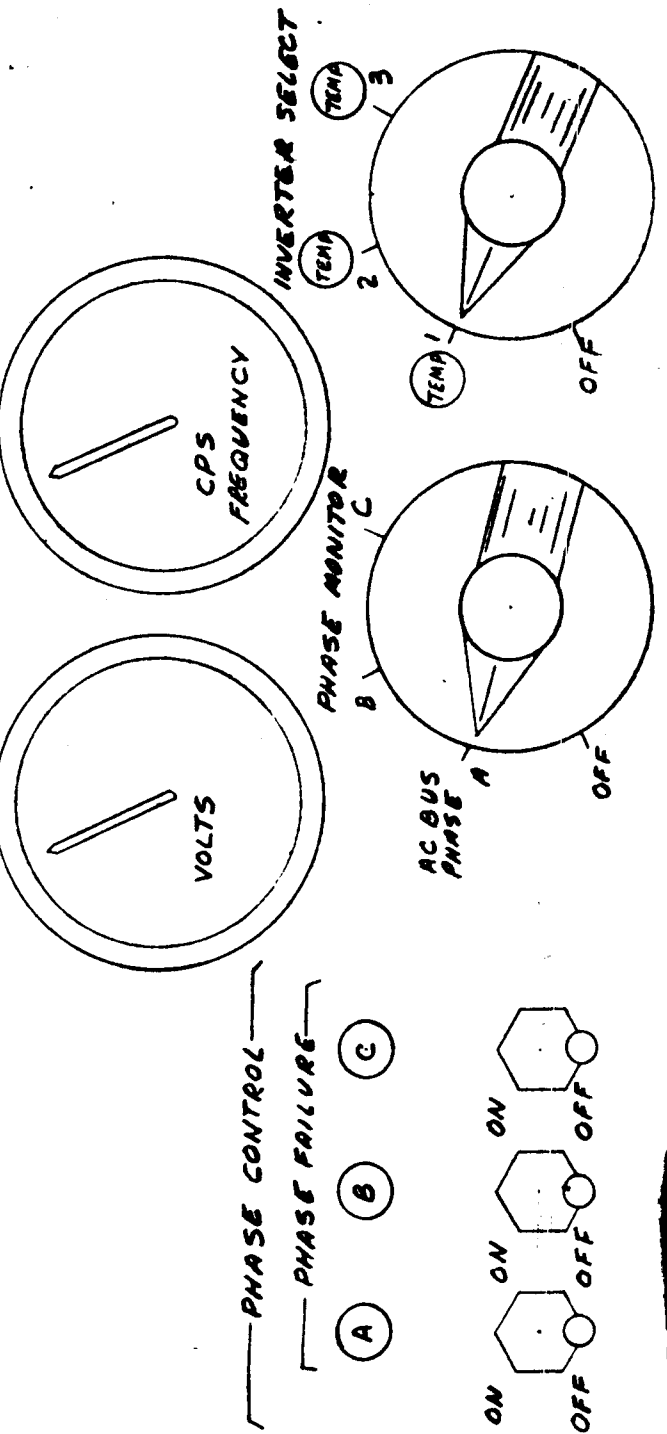


POWER DISTRIBUTION

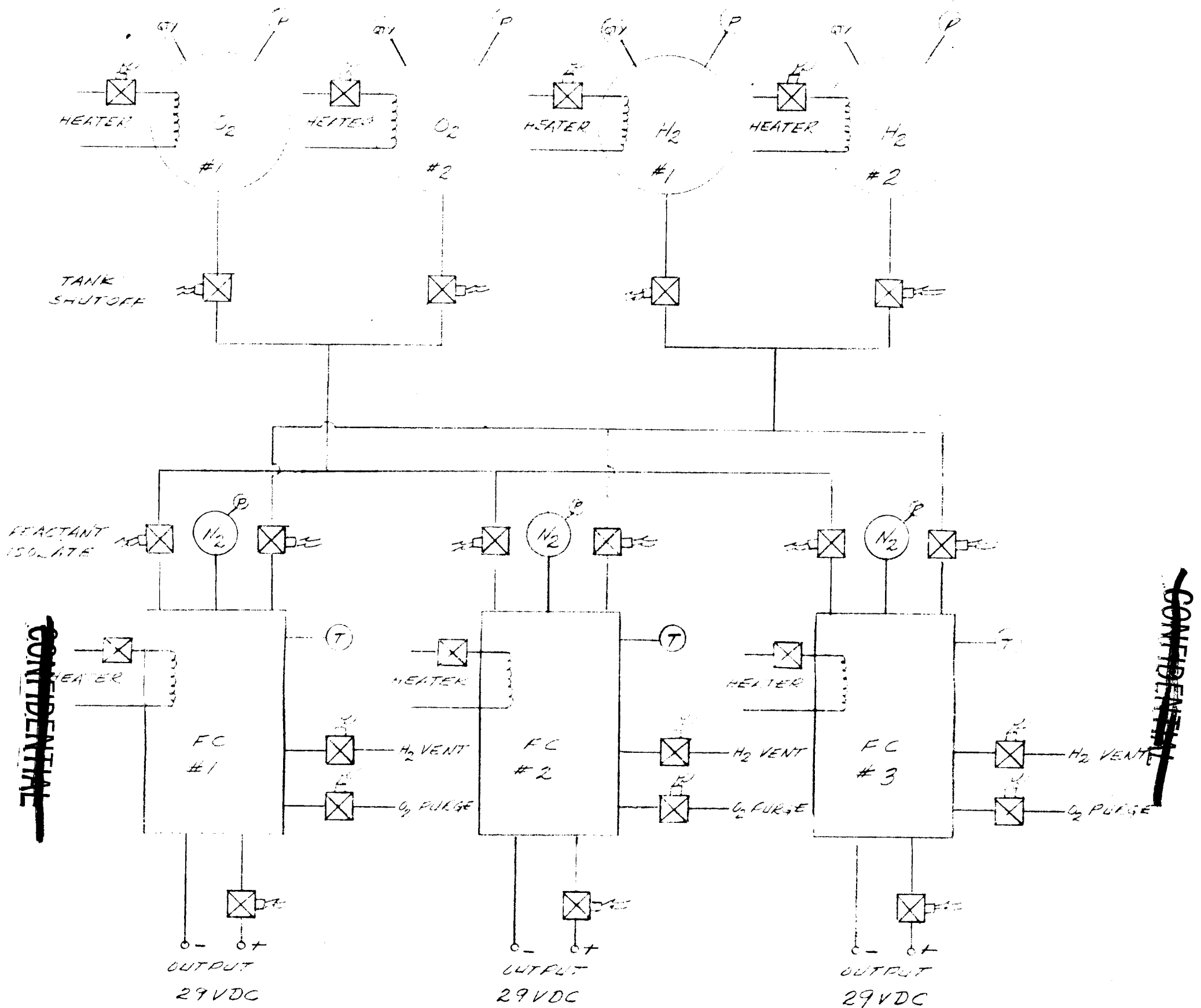
DC POWER



AC POWER



LEM POWER GENERATION SCHEMATIC (ELECTRICAL)



LEGEND



SOLENOID VALVE



HEATER



PRESSURE
TRANSDUCER



TEMPERATURE
SENSOR



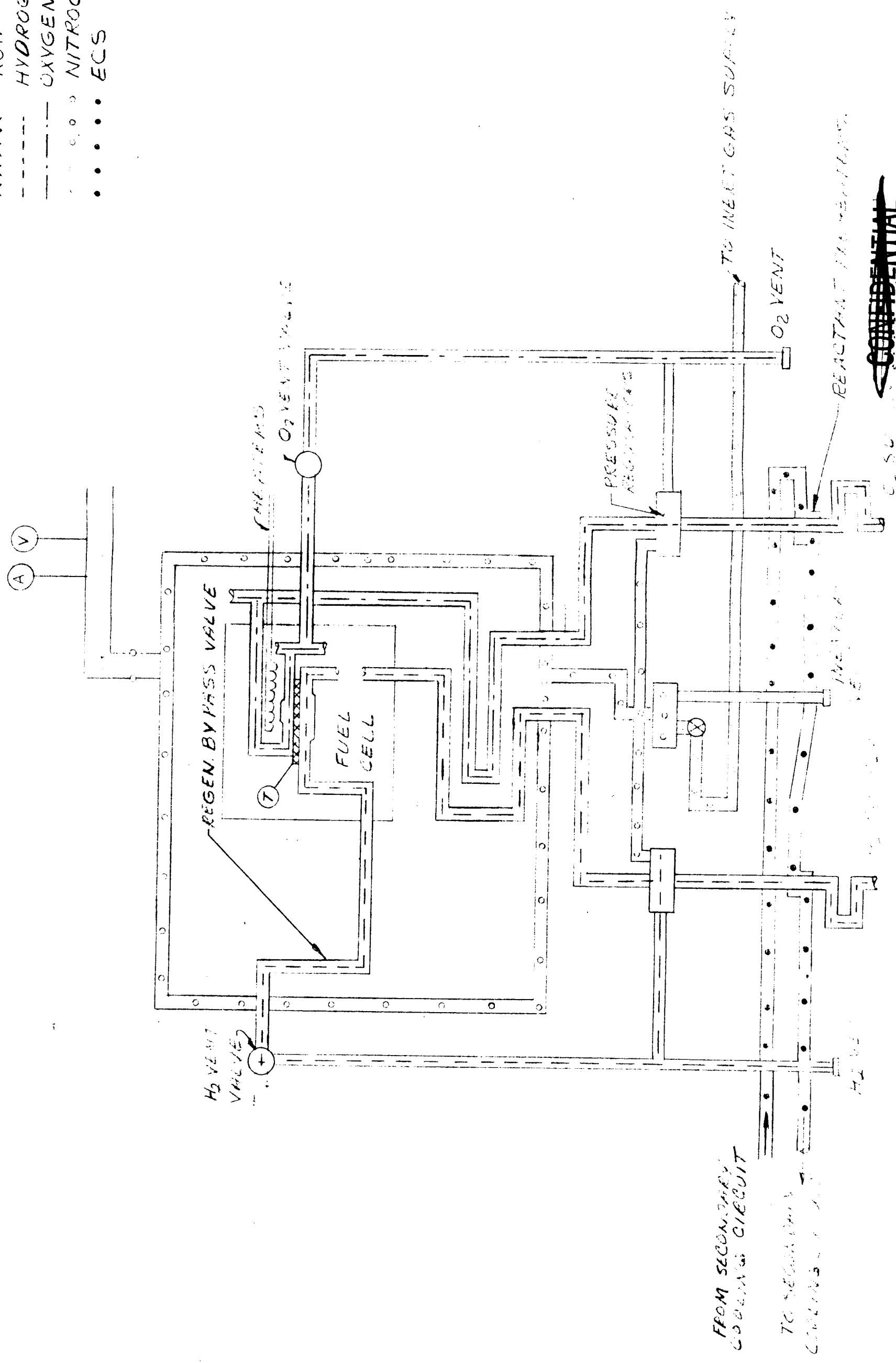
QUANTITY SENSOR
DENSITY
SENSITIVITY

FUEL CELL SYSTEM SCHEMATIC DIAGRAM

~~CONFIDENTIAL~~

LEGEND OF SYMBOL

- XXXXX KOH
- HYDROGEN
- OXYGEN
- o o o NITROGEN
- ... ECS



~~CONFIDENTIAL~~